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# ANNALS OF SURGERY

A MONTHLY REVIEW OF SURGICAL SCIENCE AND PRACTICE

EDITED BY  
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OF NEW YORK.

WITH THE COLLABORATION OF

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# ANNALS *of* SURGERY

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No. 1

## FURTHER OBSERVATIONS ON THE RESULTS OF BLOOD TRANSFUSION IN WAR SURGERY

WITH SPECIAL REFERENCE TO THE RESULTS IN PRIMARY HEMORRHAGE

BY L. BRUCE ROBERTSON, M.B. (TORONTO), MAJOR C.A.M.C.

WITH A NOTE BY

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CONSULTING SURGEON, B. E. F.

IN a previous paper<sup>1</sup> the results of blood transfusion in a few cases of secondary hemorrhage were given, with a description of the Lindeman syringe-cannula method.<sup>2</sup> Since that time opportunity has arisen of extending its application to cases of severe primary hemorrhage accompanied by shock. The results of these cases are presented in this paper. In four cases of this series the citrate method was used; one case was done with the Unger two-ways stop-cock. The remainder were done by the Lindeman syringe-cannula method.

The results have shown: First, that certain cases heretofore considered as inoperable, and others as exceedingly bad surgical risks, often may be revived to a degree which not only permits of radical operative measures, but ensures a good prospect of ultimate recovery. Second, in other cases in which the post-operative condition is one of progressively increasing shock, due to the initial loss of blood and to the severity of the operative measures required, blood transfusion is a permanent resuscitative measure of extreme value.

It has been the unhappy lot of every surgeon in a casualty clearing station to have cases admitted under his care which from an operative standpoint required immediate attention, but which were in such a collapsed and exsanguinated condition that operation was quite out of the question. In certain of these cases a short operation (frequently amputation) is all the immediate operative treatment necessary, but the patient is unfit to withstand any operation owing to loss of blood and shock. Case 10 is typical of this class.

*The Time for Blood Transfusion.*—The time at which blood transfusion should be done is a point which merits the closest attention. If the bleeding point can be controlled, as, possibly, in the case of a shattered leg or thigh, the ideal time is as soon as the patient is seen. If operative interference is

<sup>1</sup> Robertson, L. B.: Brit. Med. Journal, July 8, 1916.

<sup>2</sup> Lindeman, Edward: Amer. Jour. Dis. Child., July, 1913.

necessary before the bleeding can be controlled, *e.g.*, in intra-abdominal hemorrhage, blood transfusion may be carried out before the patient leaves the operating table. Usually, however, one is tempted to employ the ordinary resuscitative measures before resorting to blood transfusion, and in this connection it is wise to sound a warning that one should not wait too long.

Clinical observation appears to show that some degenerative changes take place in the organism when the exsanguinated condition persists for more than a few hours. If the patient is allowed to reach this stage he does not receive the same amount of benefit from the transfusion, as he would if it were given earlier. For this reason it is advisable to give the blood as soon after admission as circumstances permit.

Other great factors besides loss of blood in the production of that complex condition called shock are loss of body heat and physical exhaustion. After blood transfusion has been done these other factors may be combated by providing warmth and rest for a few hours before operation. Acidosis incident to the shocked condition may be treated by the administration of sodium bicarbonate.

With regard to the development of sepsis in these severely wounded and exsanguinated patients, it is obvious that there is a greater liability to the development of severe infection during their subsequent progress than if the anæmia were decreased by the addition of fresh blood. The benefit of blood transfusion has its limitations and it should not be used indiscriminately. It is, for example, of more limited value where gas gangrene has already developed, and should not be done unless the infected area can be either brought under control by excision or free drainage, or eliminated by amputation.

*Amount of Blood to be Transfused.*—This depends largely upon the giving capacity of the donor and the receiving capacity of the patient. A small patient will require proportionately less blood than a large heavily-built patient to produce the same effect on pulse and blood-pressure. In the cases of severe primary hemorrhage 700 to 1000 c. cm. may be regarded as an average amount, and will usually tide the patient over his crisis. Smaller amounts have been given with some success, but the most immediate and lasting improvement has been obtained with the large amounts. Cardiac dilatation in these exsanguinated recipients has not been observed even with the larger amounts given. In transfusing 1000 or 1200 c. cm. the intervals between the injections of the blood-filled syringes should be longer towards the latter part than at the beginning of the procedure, and the minimum amount of saline should be introduced into the recipient's vein between the injections of the blood-filled syringes.

In different donors the effects of loss of blood will show themselves at different times according to the size and robustness of the donor, the amount of blood, and the rate at which it is removed, and the particular method employed. An impressionable donor will exhibit symptoms earlier than one

of phlegmatic temperament. In none of the donors has anything more than a temporary disturbance been observed. This coincides with the observations made by Colonel Fullerton,<sup>3</sup> who had the opportunity of keeping donors under observation for some considerable time after they had given blood to patients.

The advisability of transfusing blood in the following cases was determined by the general condition of the patient, the pulse, and evidence of severe hemorrhage, the prospect of recovery after transfusion and operation, and in the later cases the blood-pressure. A wounded man who has lost much blood and has a blood-pressure below 90 mm. Hg is not a good subject for operation; with a blood-pressure below 70 mm. Hg he is

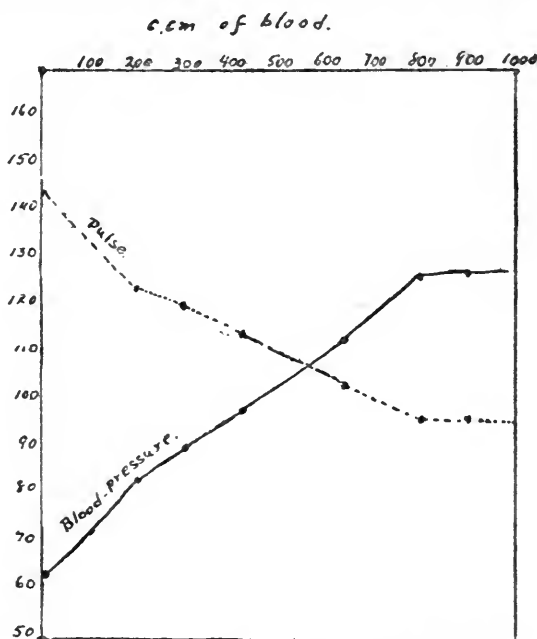


FIG. 1.—Chart of Case XXIII, showing fall in pulse-rate and rise in blood-pressure during the course of the transfusion of 1000 c.cm. of blood.

in a precarious condition. Loss of blood intensifies to a very great degree the amount of shock produced by traumatism, and in the majority of such cases the immediate issue depends upon control or elimination of the effects of hemorrhage.

*Immediate Results.*—In the cases of severe primary hemorrhage accompanied by shock blood transfusion frequently produces an immediate and almost incredible improvement. The change from a pallid, sometimes semi-conscious patient with a rapid flickering pulse to a comparatively healthy-looking, conscious and comfortable patient with a slower and fuller pulse is dramatic evidence of the value of the transfused blood. The blood-pressure readings before and after blood-transfusion have shown the re-

<sup>3</sup> Fullerton, A., Dreyer, G., and Bazett, H. C.: *Lancet*, May 12, 1917.

markable change produced by the new blood. In these cases in which readings were taken during the subsequent 48 hours it was shown that this rise in blood-pressure was well maintained. This is in marked contrast to the transient effect on the blood-pressure of normal saline injections. The accompanying chart (Fig. 1) illustrates the gradual fall in pulse rate and rise in blood-pressure during the blood transfusion. The immediate result of the transfusion is that it places the patient more on a footing with a man similarly wounded who has not lost more than a moderate amount of blood.

## CASE REPORTS

CASE I.—Rfn. T. M., admitted November 23, 1916, in extreme collapse. Compound fracture left femur, femoral vessels severed. Intravenous saline was followed by temporary improvement for some hours, but condition was still inoperable. Blood transfusion (800 c. cm. by Unger two-ways stop-cock) done. Immediate improvement. Amputation above fracture. Death in 36 hours from gas-gangrene.

CASE II.—Pte. J. S. S., admitted December 10, 1916, shattering fracture of leg involving knee-joint; profuse bleeding. Had received intravenous saline at Field Ambulance. Condition of collapse; pulse 134 and barely perceptible. Blood transfusion (500 c. cm. by citrate method); moderate but definite improvement. Two hours later, amputation above knee. Next morning pulse 82, general condition immensely improved. Further progress uneventful. Evacuated to base in two weeks. Note from England four months later stating that re-amputation had been done; stump healed rapidly; patient's health good.

CASE III.—Driver F. H., admitted December 29, 1916, in poor condition. Left foot blown away, severe compound fracture right foot, and penetrating wounds both knee-joints. Anti-shock measures carried out, and when some improvement had taken place wounds were dealt with. Post-operative condition bad. One litre of gelatin solution (Hogan) intravenously—some improvement. Following morning condition very poor—blood transfusion done (750 c. cm. citrate method). Marked reaction but some improvement, which was only temporary. Died in 20 hours. Hæmoglobinuria present. There is no doubt that death was hastened by the occurrence of hæmolytic.

CASE IV.—Sapper B. O. J., admitted January 6, 1917, under the care of Captain S. J. Streight, C. A. M. C. Had bled profusely from a ragged perforating wound of left shoulder. Compound fracture of scapula and head of humerus. Anti-shock measures instituted. Twelve hours later operation was done; shattered humeral head removed, torn circumflex vessels tied. Post-operative condition became progressively worse. Six hours after operation blood-transfusion (760 c. cm. by citrate method). Improvement immediate. Before transfusion blood-pressure, systolic, 75; diastolic, 40. Next morning: systolic, 100, and diastolic, 75; improvement progressive. Evacuated to base 4 days later. Two months later he died at a base hospital from empyema fol-

lowing pneumonia. The progress of the wound had been slow but good.

CASE V.—Pte. R. F., admitted February 3, 1917, in collapse. Severe multiple wounds of both lower limbs (left leg almost severed), and left forearm and hand. Anti-shock measures instituted. Ten hours later, when some improvement had occurred, operation was done. Intravenous saline at operation. Post-operative condition very poor. Blood-transfusion (660 c. cm. by citrate method) done 5 hours later. Slight improvement which was not maintained. Died 7 hours later from shock.

CASE VI.—Pte. T. B., admitted in night of February 7, 1917, in very poor condition. A shell fragment had severed left popliteal artery, and condition had been so bad that he had been unfit for transport from Field Ambulance for several hours. Anti-shock measures were instituted and some hours later blood-transfusion (700 c. cm.) done. Three hours later amputation above seat of injury. Patient withstood operation well, but gas-gangrene was present in the stump the next day. Infection controlled by free incision. Five days after amputation died very suddenly with signs of pulmonary embolus. Autopsy disclosed long clot extending from tied end of femoral vein to junction with internal iliac vein.

CASE VII.—Pte. A. T. H., admitted February 27, 1917, bullet wound penetrating abdomen. Sixteen hours after laparotomy pulse became much weaker and more rapid. Blood-transfusion (1000 c. cm.) done: remarkable and immediate improvement, pulse dropping from 140 before to 108 after transfusion. Patient died 30 hours later from gas-bacillus infection in a large retroperitoneal hæmatoma.

CASE VIII.—Pte. T., admitted April 21, 1917, under the care of Captain William Beggs, C. A. M. C., in severe collapse. Bleeding from a shattered forearm had been profuse. Anti-shock measures. Five hours later circular amputation done. Post-operative condition became progressively worse for five hours, when blood-transfusion (1160 c. cm.) was done. Immediate improvement. Before transfusion: radial pulse 120 and barely perceptible, lips and face colorless. After transfusion: pulse 85 and of good tension, face showed much improved color. Four days later: secondary amputation, flaps closed. Evacuated to base on fourth day in excellent condition.

CASE IX.—Cpl. F., admitted under the care of Captain Beggs, C. A. M. C. Severe multiple wounds of arms and legs. General condition very poor. Anti-shock measures for some hours, then amputation of left leg and other wounds dealt with. The following day general condition poor—blood-transfusion done (500 c. cm.). Immediate improvement. Further progress steady though slow. Evacuated to base on 4th day. Note received from base to the effect that patient had been evacuated to England in satisfactory condition after severe illness.

CASE X.—Lieut. V., admitted May 17, 1917, wounded 7 hours previously. Left leg and knee shattered, popliteal vessels torn, penetrating wounds left thigh, buttock, face. Radial pulse 120, but almost



imperceptible; face blanched. Anti-shock measures, but one hour later radial pulse imperceptible and blood-pressure below 40 mm. Hg. Death seemed imminent. Blood-transfusion (1100 c. cm.) done. Immediate improvement. After transfusion: pulse 130; blood-pressure, systolic, 120, diastolic 90. Half an hour later amputation above knee and other wounds dealt with. Apart from transient sepsis on the face of the stump, due to amputation having been carried through at the level of other wounds, progress was uneventful. Evacuated to base eight days later in very good condition.

CASE XI.—Sapper W. C., admitted May 18, 1917, in severe collapse; wounded seven hours previously. Had bled profusely from shattered left elbow and forearm. Blood-transfusion (1200 c. cm.) done immediately: marked improvement. Before transfusion: pulse 154; blood-pressure systolic 62, diastolic 0. After transfusion: pulse 130; blood-pressure systolic 110, diastolic 80. Seven hours later amputation above elbow. Two hours after operation: pulse 114; blood-pressure systolic 120, diastolic, 80. Further progress uneventful. To base in six days in good condition.

CASE XII.—Pte. J. J., admitted May 18, 1917, lower part of left leg blown away six hours previously. Patient collapsed and blanched. Blood-transfusion (900 c. cm.) done. Immediate improvement. Before transfusion: pulse 146; blood pressure systolic 74, diastolic 20. After transfusion: pulse 92. Half an hour later amputation below the knee. Seven hours after operation: pulse 118; blood-pressure systolic 128, diastolic 70. Further progress good. Evacuated to base in six days. Two weeks later a note from England stated "flaps fairly clean—slow progress."

CASE XIII.—Pte. W., admitted May 29, 1917, five hours after having sustained a severe comminuted fracture of the femur extending into the knee-joint. Condition of collapse. Blood-transfusion (1000 c. cm.) done. Immediate improvement in general condition and appearance. Before transfusion: pulse 120, blood-pressure 96. After transfusion: pulse 100, blood-pressure 110. Amputation above knee. Patient withstood operation well but died three days later of acute capillary bronchitis.

CASE XIV.—Pte. W. C. N., admitted June 1, 1917. Shattered right leg; was blanched and had bled profusely. Blood-transfusion (1060 c. cm.). Immediate improvement. Before transfusion: pulse 112; blood-pressure systolic 90, diastolic 32. After transfusion: pulse 76; blood-pressure systolic 134, diastolic 100. Half an hour later amputation above knee. The following day patient was in excellent condition and was evacuated to base.

CASE XV.—Driver L. H. B., admitted May 29, 1917, under the care of Captain S. J. Streight, C. A. M. C. Severe compound fracture right tibia and fibula into knee-joint, shattered right elbow and forearm, penetrating wounds of right thigh. Anti-shock measures instituted. Amputation above right knee and elbow, other wounds dealt with. Post-operative condition became progressively worse. Five hours after operation blood-transfusion (900 c. cm.) done. Before trans-

## BLOOD TRANSFUSION IN WAR SURGERY

fusion: pulse 136; blood-pressure systolic 86, diastolic 54. After transfusion: pulse 120; blood-pressure systolic 140, diastolic 74. Progress uneventful; evacuated to base on fourth day in good condition.

CASE XVI.—Second Lieut. M., admitted in severe shock and collapse, wounded seven hours previously. Left forearm shattered, penetrating wounds of right knee-joint, calf and foot, right ankle disorganized by large perforating wound, large dirty perforating wound left loin opening extra-peritoneal space. Condition quite inoperable. Anti-shock measures of little avail. Blood-transfusion (1100 c. cm.) done. Immediate improvement. Before transfusion: pulse 132; blood-pressure systolic 90, diastolic 32. After transfusion: pulse 140; blood-pressure systolic 120, diastolic 74. Four hours later under gas and oxygen amputation of left arm (gas gangrene), loin wound thoroughly excised, other wounds dressed. Following day amputation above right knee. Further progress uneventful. To base four days later. A note was received from the base stating that ten days later flaps were sutured, and three weeks after being wounded he was evacuated to England, "the wounds healing nicely and condition much improved."

CASE XVII.—Lieut. H., admitted in shocked condition, penetrating wound of abdomen, excessive amount of blood vomited. Laparotomy disclosed perforated stomach and active bleeding from severed gastropiploic artery, abdominal cavity full of bright blood. After operation: pulse almost gone, patient very blanched. Blood-transfusion (1000 c. cm.) done. Before transfusion: pulse 130; blood-pressure systolic 66, diastolic 0. After transfusion: pulse 92; blood-pressure systolic 170, diastolic 72. High systolic pressure due to injection of pituitrin given at the end of operation. During transfusion there was slight respiratory distress after 140 c. cm. of blood had been injected, but it was difficult to judge on account of the effects of the anæsthetic. Two hours later pulse became weaker and patient died in a few hours. At autopsy some hæmoglobinuria was evident. There is no doubt that a hæmolytic reaction due to the transfused blood hastened the death of this patient.

CASE XVIII.—L.-Cpl. A., admitted June 7, 1917, wounded the previous day, perforating wounds of both legs severing both posterior tibial arteries. Practically moribund condition—inoperable. Anti-shock measures carried out in resuscitation ward with little effect. Some hours later gas gangrene was evident in both legs, patient unconscious and pulseless. At this time it was thought that blood-transfusion followed by operation would give him his only chance. Blood-transfusion (1000 c. cm.) done. Response extraordinary. Breathing, which at first was shallow and sighing, became quiet and regular; pulse grew perceptible and though rapid was of good character. Color returned to his face, and half-way through the procedure he became conscious. At the end of the transfusion he was quite conscious and talked rationally. Half an hour later double amputation above knees was done under gas and oxygen, but patient died at end of operation. Had circumstances allowed of an earlier transfusion being done I feel sure that a successful result might have been expected.

CASE XIX.—Capt. A. C. T., admitted June 13, 1917, wounded five hours previously. There had been profuse hemorrhage from shattered leg. Pulse only 108, but of low tension. Immediate amputation for persistent bleeding from popliteal space. Post-operative condition progressively worse. Two hours later patient very collapsed and could be roused only with difficulty. Blood-transfusion (1100 c. cm.). Before transfusion: pulse 108; blood-pressure systolic 66, diastolic below 20. After transfusion: pulse 84; blood-pressure systolic 120, diastolic 66. Half-way through transfusion patient was quite conscious; at the end of the procedure he asked for a cigarette and smoked it with enjoyment. Further progress uneventful. To base in five days. Note from base stated "condition suitable for immediate transference to England."

CASE XX.—Gunner W., admitted June 18, 1917, six hours after being wounded. Left thigh almost completely blown away below middle. Condition of severe shock and collapse. Blood-transfusion (700 c. cm.) done. Immediate improvement. Before transfusion: pulse 130; blood-pressure systolic 80, diastolic 50. After transfusion: pulse 92; blood-pressure systolic 124, diastolic 78. Following this amputation was done, but patient withstood the operation badly and died ten hours later from shock.

CASE XXI.—Capt. G. S. T., admitted June 17, 1917, under the care of Capt. S. J. Streight, C. A. M. C., in collapsed condition. Right leg shattered, compound fracture right great trochanter, penetrating wound of arm. Blood-transfusion (1200 c. cm.) done. Before transfusion: pulse 134; blood-pressure systolic 70, diastolic 40. After transfusion: pulse 94; blood-pressure systolic 128, diastolic 80. Four hours later amputation below knee and other wounds dealt with. To base in four days. Later a note was received from the base stating that he had been evacuated to England in satisfactory condition.

CASE XXII.—Pte. F. McL., admitted July 4, 1917. Buried by a shell seven hours previously. Condition of shock and collapse from intra-abdominal injury and fracture of femur. Anti-shock measures for some hours produced slight improvement. Laparotomy done: abdomen full of bright blood and urine. Two-inch tear in bladder, lower part of spleen completely torn away, profuse spurting of blood from the remainder at the first touch. Splenectomy and bladder suture. Thomas splint to thigh. During operation pituitrin (1 c. cm.) was given, and saline (30 ounces) introduced into vein. At end of operation patient very blanched and pulse poor. Blood-transfusion (1000 c. cm.) done. Before transfusion: pulse 180; blood-pressure systolic 89, diastolic 40. After transfusion: pulse 140; blood-pressure systolic 185, diastolic 80. High systolic pressure evidently due to pituitrin, as seven hours later it had dropped to 136, diastolic being maintained at 80. Further progress uneventful. To base in two weeks. Four weeks after operation a note was received from the base stating that patient was in excellent condition and recovery was assured.

CASE XXIII.—Pte. G. G. H., admitted July 11, 1917, in severe collapse. Compound fracture of left leg, rupture of both tibial arteries,

large wound of right leg with tear of posterior tibial artery. Had bled profusely. Anti-shock measures instituted—little improvement. Blood-transfusion (1000 c. cm.) done. Immediate improvement. Before transfusion: pulse 144; blood-pressure systolic 62, diastolic 40. After transfusion: pulse 96; blood-pressure systolic 126, diastolic 60. Several hours later amputation of left leg below knee, other wounds dealt with. Further progress uneventful. To base in four days in good condition. Note received from the base stated that he had been evacuated to England in good condition three weeks after being wounded.

CASE XXIV.—Pte. F. S., admitted in collapsed condition on July 12, 1917, seven hours after being wounded. Shell wounds left buttock, leg and foot, right popliteal artery severed, and severe fracture of femur involving right knee-joint. Anti-shock measures carried out with only temporary improvement. Four hours later blood-transfusion (1000 c. cm.). Before transfusion: pulse 156; blood-pressure 80. After transfusion: pulse 120; blood-pressure 136. Three hours later amputation above right knee, and other wounds dealt with, under gas-oxygen anæsthesia. Five hours after operation: pulse 128; blood-pressure 120. Further progress uneventful. Evacuated to base on fifth day in good condition with clean wounds and stump.

CASE XXV.—Dr. C. J. B., admitted in very grave condition under the care of Maj. G. E. Gask, D.S.O., R.A.M.C. (T). Penetrating wound of chest, tear of left femoral vein, penetrating wound of right knee-joint. After operation patient was blanched and collapsed; pulse was 130 and barely perceptible; blood-pressure 60 mm. Hg. Blood-transfusion was started, but before 60 c. cm. had been injected death was imminent. The patient's lips were bloodless, pulse imperceptible, breathing slow and jerky. Eighty c. cm. of very hot saline and 1 c. cm. pituitrin were now given intravenously, and the transfusion continued. When 400 c. cm. of blood had been injected the breathing had improved greatly. At the end of the transfusion (1200 c. cm.) the face was flushed, pulse strong, and patient was attempting to clear his throat. After transfusion: pulse 108; blood-pressure 144. Further progress uneventful—evacuated to base seven days later. Two weeks later word was received from the base that patient had been evacuated to England in good condition.

CASE XXVI.—Gunner E. G., admitted in very collapsed condition under the care of Maj. G. E. Gask, R.A.M.C. (T) on July 17, 1917. Severe penetrating wound of chest, extensive damage to lung. Had been wounded early that morning. Blood-transfusion (700 c. cm.) done. There was slight response, lasting a very short time. Death occurred some five hours later. Autopsy showed gas bacillus infection in hæmothorax and severe laceration of lung.

CASE XXVII.—Gnr. C. H. W., admitted on July 25, 1917, in collapsed and pulseless condition. Large penetrating wound of lower abdomen. Anti-shock measures were instituted and pulse returned—rate 96. Laparotomy eight hours after wound was received, resection 18 inches small gut suture of bladder and two tears in rectum. The

abdomen was filled with blood and clot; after operation patient was pulseless. Blood-transfusion (1100 c. cm.) was done, but patient was too far gone to benefit by it and died in less than three hours.

CASE XXVIII.—Lieut.-Col. R.A.M.C., aged fifty, was admitted in collapsed condition seven hours after being wounded, pulse almost imperceptible, face grayish-blue, condition inoperable. Severe compound fracture below right knee, penetrating wound right knee-joint, right hand blown off, left brachial artery severed, large perforating wounds left thigh. Blood-transfusion (1200 c. cm.) was done. Immediate improvement. Four hours later operation was carried out under light  $\text{CHCl}_3$  anaesthesia, three surgeons being concentrated on the case; amputation above right knee, ligation of left brachial artery, excision of wounds of left thigh, amputation through right carpus. Further progress slow but good. Evacuated to base four days later; temperature 98, pulse 88. Two weeks later wounds reported to be improving.

CASE XXIX.—Second Lieut. A. D. J., admitted July 29, 1917, under care of Maj. G. E. Gask, R.A.M.C. Patient in collapsed condition, severe penetrating wound of chest from which there had been a large amount of bleeding. Condition inoperable. Blood-transfusion (740 c. cm.) carried out. After 100 c. cm. had been injected operation was begun. Thoracotomy, removal of shell fragments, irrigation of pleural cavity, closure of chest wall. Further progress good. Evacuated to base nine days later in good condition.

CASE XXX.—Pte. H. G., admitted on July 28, 1917, six hours after being wounded, in very collapsed condition. Right leg shattered and vessels torn, extensive wound of left calf with shell fragment embedded in muscles; pulse rapid and flickering, lips bluish-white. Blood-transfusion (1200 c. cm.). Two hours later amputation above right knee (for gas-gangrene), left calf widely opened up. Next morning patient was very much improved, but by evening gas-gangrene of left leg was present and amputation above left knee was done under gas-oxygen anaesthesia. The following day there was persistent vomiting (acidosis), which was relieved by an intravenous injection of 20 ounces of five per cent. soda bicarbonate solution. Further progress uneventful. Evacuated to base five days after admission in very good condition, both thigh stumps clean.

CASE XXXI.—Gnr. W. P., admitted on August 4, 1917, in collapsed condition. Right forearm shattered, compound fracture right femur with severing of popliteal vessels. Anti-shock measures carried out but only slight improvement resulted. Blood-transfusion (1000 c. cm.) done with immediate and marked improvement. Amputation through forearm and thigh now done. Patient withstood operation well, but died in 36 hours from extensive gas-gangrene of right thigh.

CASE XXXII.—Pte. D. O'L., admitted on August 5, 1917, in very collapsed condition. Forty-eight hours previously had sustained a large wound in left thigh and while lying out in a shell-hole had received a second and extensive wound in the left calf, twenty-four hours later.



There had been severe hemorrhage from the latter. Anti-shock measures were instituted, but with only slight improvement. Blood-transfusion (1100 c. cm.) done. Immediate improvement resulted. Before transfusion: pulse 132; blood-pressure 90. After transfusion: pulse 96; blood-pressure 142. One hour later operation was done. Further progress good—evacuated to the base in two days in very good condition. It is interesting to note that at the end of the transfusion there was a marked urticarial eruption (serum rash?) over the trunk and extremities. It had subsided in less than 24 hours.

CASE XXXIII.—Lieut. J. K. P., admitted on August 5, 1917, under the care of Capt. W. Beggs, C.A.M.C., in very poor condition, 24 hours after sustaining a severe compound fracture of left leg into knee-joint with damage to vessels. After anti-shock measures, drainage established and bleeding controlled. The next day pulse was very rapid, face still blanched, leg becoming swollen. Blood-transfusion (530 c. cm.) done. Before transfusion: pulse 178; after transfusion: pulse 132. Amputation above knee. Further progress uneventful. Evacuated to base on August 9 in good condition; pulse 90.

CASE XXXIV.—Pte. J. W., admitted on August 10, 1917. Wounded 12 hours before: extensive comminution of right femur, anterior muscles blown away but hamstrings intact, femoral vessels torn. Condition of profound collapse. Anti-shock measures instituted on admission with very little effect. Blood-transfusion (1000 c. cm.) two hours later. Before transfusion: pulse 152; blood-pressure 72. After transfusion: pulse 130; blood-pressure 146. Patient suffering from toxæmia due to gangrenous condition of muscles. High amputation done one hour after transfusion, but intramuscular planes found to be extensively infected up to groin. Death 20 hours later.

CASE XXXV.—L.-Cpl. L. H., admitted on morning of August 11, 1917, had been wounded the previous evening. Right leg shattered, involving knee-joint, part of right tarsus blown away. Anti-shock measures for several hours with no effect. Blood-transfusion (700 c. cm.) done. Before transfusion: pulse 152; blood-pressure systolic 60, diastolic 0. After transfusion: pulse 114; blood-pressure systolic 120, diastolic 60. Amputation above right knee. Further progress uneventful. Evacuated to base in good condition on fourth day.

CASE XXXVI.—Pte. A. H. C., admitted August 11, 1917, collapsed and almost pulseless; had bled profusely from gaping wound in right popliteal space. Anti-shock measures had very little effect. Blood-transfusion (1000 c. cm.) done. Immediate improvement. Before transfusion: pulse 124; blood-pressure systolic 74, diastolic 15. After transfusion: pulse 110; blood-pressure systolic 142, diastolic 68. Amputation above wound two hours later under gas-oxygen anæsthesia. Examination of amputated leg showed complete division of popliteal vein and large tear in popliteal artery. Further progress uneventful. Evacuated to base in good condition on fourth day.

In reviewing these cases of primary hemorrhage I feel that better results might have been obtained in cases 1, 7 and 18. In case 1 the fatal issue was due to the early development of gas-gangrene which might have

been eliminated by amputation had the transfusion been done earlier. In case 7 an earlier transfusion would have permitted earlier amputation which would have rendered less liable the development of gas-gangrene. Though the infection in this case was controlled, it was responsible apparently for thrombosis in the femoral vein with subsequent death from pulmonary embolism. Case 18 was seen during the rush of the Messines battle. Measures to counteract shock were carried out in the resuscitation ward but were unsuccessful. Although the blood-transfusion produced a startling improvement his toxæmia was too intense to allow him to withstand the anæsthetic and the shock of the operation.

## CONCLUSIONS

1. Many cases admitted in an inoperable condition from severe hemorrhage have been rendered operable by blood-transfusion.

2. The largest factor in the causation of the shocked condition as seen in patients admitted to a casualty clearing station appears to be the loss of blood, except in case of visceral injury.

3. In two cases hæmolytic hastened the death of the patient—in one of these the citrate method was used. The possibility of hæmolytic certainly is present, but the danger of its occurrence is slight in comparison with the danger of operating on a shocked and exsanguinated patient.

4. The results in this series of cases of severe primary hemorrhage may be classified as: Life saving, 22; immediately beneficial but died from infection or operation, 9; no benefit, 3; harmful, 2; total, 36.

5. Although the mortality in this series of cases is comparatively high it must be remembered that all the patients were in a desperate condition, and with perhaps one possible exception could not have been expected to survive if the procedure had been withheld.

## NOTE BY COL. C. GORDON WATSON

During the past year I have had the opportunity of observing the technic and the results of blood transfusion by Major Bruce Robertson and other workers. Without doubt transfusion of blood after primary hemorrhage is a life-saving device of the greatest value and enables urgent operations to be successfully performed under conditions otherwise hopeless. In the past blood transfusion has failed to come to the fore owing to technical difficulties. The stimulus of war and the urgent need for blood transfusion has resulted in greater familiarity with the technic.

For many years past we have in England, at any rate, trusted to saline infusion to restore the balance after hemorrhage. So far as my experience goes, there is no comparison between the results of blood transfusion and saline infusion. The effects of blood transfusion are instantaneous and usually lasting; the effects of saline too often transitory—a flash in the pan—followed by greater collapse than before. In civil practice, speaking generally, the occasions for transfusion are few; in military practice, in the

forward line, the exsanguined wounded man is a regular habitué of the reception room. The problems of shock and collapse are receiving every day greater attention.

In every casualty clearing station there is a resuscitation ward with hot beds, heated by hot air or electric light, with arrangements for giving hypertonic intravenous infusions, etc. Here we endeavor to estimate the shock of battle, the shock that follows trauma in loss of blood, or the shock of toxæmia, to assess the proportionate damages to each and to apply the appropriate remedy.

The methods of blood transfusion employed in the casualty clearing stations vary with the individual taste of the surgeon. Major Robertson has acquired great dexterity with the syringe method and his results are correspondingly good. Practice in team work is essential to success and the two surgeons and the syringe orderly must drill together. Record syringes can be relied on for the purpose: others cannot. The scope of blood transfusion is not limited to primary hemorrhage. It is of undoubted value for secondary hemorrhage and we have used it successfully also in two severe cases of CO poisoning (as a sequel to venesection). In the selection of a donor for blood transfusion certain precautions should be taken when the circumstances of the case permit. At the front, particularly during the periods of heavy fighting, time does not permit of tests to eliminate syphilitic taint nor indeed to ascertain if the blood of the donor is incompatible with that of the patient. Such risk as there is must be run if the urgent need of the patient is to be promptly met.

I have more than once seen alarming symptoms arise during transfusion. In one case the pupils dilated, the eyes were turned up, the pulse rate increased and the patient became pallid and unconscious and died the same day. At the autopsy the blood was completely hæmolyzed. The condition of the wounds, however, showed that the chances of recovery were remote. In other instances I have noted transitory respiratory distress, sweating and præcordial pain followed subsequently by a varying amount of hæmoglobinuria. The occurrence of rigors with a transitory rise of temperature is by no means uncommon after transfusion and is not an indication of incompatibility of bloods. Too rapid transfusion may be followed by acute dilatation of the heart when the myocardium is exhausted and weakened by hemorrhage and shock. As Crile has pointed out, the work of the heart increases in geometric ratio to the volume of blood, and it is easy to realize the risk involved in suddenly producing a rapid increase in the volume of blood when the heart is already tired out. I have seen this exemplified in one case.

I feel confident that blood transfusion has come to stay and that under the stimulus of war, and the mass of material that war provides, our methods will steadily improve. The excellent result which Major Robertson has secured will, I hope, stimulate other surgeons to increased activity in the practice of this life-saving device.

## THE USE OF DICHLORAMINE-T IN THE TREATMENT OF INFECTIONS AND INFECTED WOUNDS\*

BY LIEUTENANT WALTER E. LEE, M.R.C.

AND

CAPTAIN WILLIAM P. FURNESS, M.R.C.

THE experience of nearly two and a half years at the hospital of the American Ambulance in Paris has been in accord with that of the majority of surgeons who have served in the present war, namely, that the chlorine preparations have proven in our hands superior to all other germicidal agents. It was soon found, however, that all of the standard hypochlorite preparations, as eau de Javelle, Labarraque's and the eusol solutions, were very irritating to the skin if used for any length of time. In order to minimize this irritation, various modifications of the original formulæ were tried, the most successful of which was that of Dakin, a very dilute, neutral, Labarraque's solution. This neutral hypochlorite solution was found to have three inherent faults.

First: The neutral solution, unlike the original Labarraque's with its free alkali, was very unstable and it was necessary to prepare it almost daily.

Second: The dilute 0.48 per cent. solution contained such a very small mass of germicide, if the concentration was even slightly lowered, *e.g.*, to 0.4 per cent., the germicidal efficiency was very materially impaired, that it was necessary, in order to obtain a maximum effect, to have the solution all times in contact with the surface of the wound.

Third: The active chlorine was used up so rapidly from the solution when it came in contact with the wound exudate, from seven to fifteen minutes as estimated by Carrel, that it was necessary to frequently renew the supply of germicide, at least every two hours night and day.

Carrel, Dehelly and Depage gradually overcame all these inherent faults of the weak neutral hypochlorite solutions of Dakin and Daufresne by developing a beautiful but complicated technic for their application. And with this technic they were able to obtain wonderful results in the treatment of infected wounds.

It is generally conceded that they have demonstrated conclusively:

First: That if infected wounds are treated with the same aseptic surgical care that surgeons give to clean wounds, very unusual results can be obtained.

Second: That the primary dressing of infections and infected wounds should be made a formal aseptic operation in which all devitalized and infected tissue should be removed, with knife, forceps and scissors, that it is mechanically practical and anatomically justifiable to sacrifice.

Third: That infected wounds so treated can be sterilized if the wound surfaces are constantly bathed with even such a small mass of germicide as is contained in the aqueous hypochlorite solutions. This constant immersion

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\* Read before the Philadelphia Academy of Surgery, October 1, 1917.

can be accomplished by Carrel's complicated hydraulic system of reservoirs and tubes.

Fourth: That when the wound surfaces are practically clean, one bacterium per five microscopic fields on three successive counts made every third day, the wound edges may be approximated by sutures and union may be expected to take place without infection in about 80 per cent. of the cases.

Many have had the privilege of seeing the work of Carrel and Depage and can personally testify to the accuracy of their claims, but the indifferent success most of us have had in trying to obtain similar results, Carrel himself says, is because of our failure to grasp and apply the details of the technic. The Carrel technic demands an unusual degree of painstaking and time-consuming care, not peculiar skill, upon the part of the surgeons, nurses and chemist, and the unusual expense for both the apparatus and dressing material develops difficult problems for the entire personnel of even our civil hospitals.

Now it is essential in this technic of Carrel to so prepare the wounds at the primary operation that they will act as basins for retaining the hypochlorite solution during the period of repair. Thus the cardinal principle of surgery, dependent drainage of infected cavities, must be abandoned if this treatment is to be used. In spite of this, if the wounds are subsequently treated with the aqueous hypochlorites with the infinite care Carrel practises, the results will be far better than with any other treatment we have used in the past. But, if for any reason this perfect hydraulic system breaks down, and it is very vulnerable, these wounds prepared in this way act as pus pockets, and, as has been expressed by many military and civil surgeons, such wounds give unfortunate results.

We must not forget in our admiration for the Carrel technic, that it was because of the severe skin irritation produced by the standard hypochlorite preparations that Dakin first suggested his modified Labarraque's solution; and that because of the inherent faults of this Dakin's solution, instability, the very small mass of germicide contained, and the rapidity with which it liberated its chlorine, it was necessary to develop an unusual technic to make such a solution effective in the treatment of infected wounds.

Or this might be stated in another way, that the Dakin's solution and Carrel technic represent an effort to modify Labarraque's solution and the method of its application to infected wounds in such a way that there will be a minimum of the dreaded skin irritation produced by the original Labarraque's formula.

These facts were soon realized by Dakin, and he started a new search for a more effective germicide. If possible a chlorine compound which would be non-toxic and non-irritating to both the surface of the wound and to the skin and which could be placed in contact with the infection in a menstruum that would be capable of containing not only the desired mass of germicide, but also of holding in solution a reserve mass over a long period of time.

In these investigations, he found that the various hypochlorite prepara-

tions used in the treatment of infected wounds react with proteins of any kind, and one of the first reactions consists in the amido-groups uniting with the active chlorine to form substances containing the NCl group.

These products, which belong to the group of chloramines, possess marked bactericidal properties, and are the active germicidal agents produced by the hypochlorites when they come in contact with the wound exudate. These chloramines are non-irritating to animal cells and this explains the absence of irritation in the wounds where the irritating active chlorine of the hypochlorite has been changed into chloramines and other non-irritating protein derivatives.

It is quite simple to produce many of these chloramines synthetically. The first one to be used was in the form of a sodium salt of toluene-para-sulphon-chloramide or Chloramine-T and sold in this country under the trade name of chlorazene. This synthetic chloramine was non-irritating to the skin and could be used in aqueous solutions in 2 to 4 per cent. strengths, but it had the same fault as the aqueous hypochlorite in that its active chlorine is liberated very rapidly, and though the difficulty of the skin irritation was obviated, it was still necessary to frequently renew the solution as with the aqueous hypochlorites.

Dr. Dakin entrusted to us the honor of testing the surgical value of another synthetic chloramine at the Pennsylvania Hospital, toluene-para-sulphon-dichloramine, which he called Dichloramine-T. This preparation was dissolved in chlorinated eucalyptol and could be used in strengths varying from 5 to 20 per cent. By using oil as a menstruum a large mass of germicide was brought to the infection and yet held so firmly in solution that it very slowly diffused into the surrounding medium for at least as long as eighteen to twenty-four hours, and during this period a mass of germicide was at all times active, which was equal to that given off during the first seven to fifteen minutes by the hypochlorite solution.

Theoretically then, this new chlorine compound eliminated at the start the chief indication or necessity for the Carrel technic, skin irritation. With such a solution, it should be possible to present to an infection an overwhelming mass of germicide, a 20 per cent. solution of dichloramine being approximately 80 times the germicidal mass of a 0.48 per cent. hypochlorite solution. There is a vital necessity, when using germicides in the treatment of infections, for the earliest possible application of an overwhelming mass of a rapidly acting agent, because infection develops in the tissues at the rate of a geometric progression and not by the slow process of addition, and therefore every minute counts in the end result. Dichloramine, with a phenol oil coefficient of about 50, can be presented in a larger mass without injury to the tissue cells than any other germicide we have used. Instead of having this chlorine given up with explosive rapidity and the consequent necessity of frequent renewals of the solution, it would be slowly diffused into the surrounding media, making it unnecessary to renew the solution or to dress the wounds more frequently than once in every twenty-four hours.

## DICHLORAMINE-T IN WOUNDS

Five months have elapsed since the writing of the first report upon the use of Dichloramine-T in the treatment of infections and infected wounds. We have now the records of 6028 civil cases in which the germicide has been used and of four months' work and 1200 cases reported by Captain Joshua Sweet with war wounds in the U. S. Base Hospital No. 10 in France. From this clinical experience the conclusions tentatively offered in our first report have developed into firm convictions.

Three thousand three hundred and eleven cases are reported by Dr. Robert P. Cummins from the surgical dispensary of the Midvale Steel Works.

Two thousand two hundred and seventy-one cases reported from the Pennsylvania Hospital from the surgical services of Dr. Robert G. LeConte, Francis T. Stewart and Walter E. Lee, and of the work of Dr. Robert C. McIver.

Two hundred and seven from the Germantown Hospital in the service of Dr. Walter E. Lee and the work of Dr. Robert Kelly and Dr. Robert Regester.

One hundred cases from the St. Agnes Hospital by Dr. G. M. Dorrance.

Fifty cases from the Children's Hospital in the service of Dr. Walter E. Lee and by Dr. Edgar Christy.

Eighty-nine cases from the Jefferson, Lankenau and Episcopal Hospitals.

From the records of 3311 cases at the Midvale Steel Works, it has been possible to make a comparison between the efficiency of tincture of iodine and Dichloramine-T. A period of four and a half months in 1916, when iodine was exclusively used, was compared with the same period of time in 1917 when Dichloramine-T was used. The results with Dichloramine-T were 60 per cent. better than with iodine.

An interesting comparative study was made at the Pennsylvania Hospital between the Carrel technic and Dakin solution and Dichloramine-T applied with the technic to be demonstrated on the screen. With the working factors as nearly the same as it is possible to have them, same surgeon, nurses and surgical asepsis and the same class of injuries, a total of 157 industrial injuries were treated by the Carrel technic and Dakin's hypochlorite solution with an average healing time of 14.4 days. The succeeding three months Dichloramine-T with a simplified technic was used in the treatment of 281 cases with an average healing time of 10.4 days.

At the Pennsylvania, Germantown and Children's Hospitals, there have been 2528 cases under our direct personal supervision. In the 825 cases of infection there was but one case in which a localized process was not controlled and in which there was a secondary involvement of tendon, bone or joint. In this group there were 60 cases of bone infection, and yet in no instance was it necessary to amputate because of infection. There is no doubt that the period required for healing has been considerably less than that with any other germicide we have used.

There has been a total of 1651 lacerated and infected wounds. When mechanically possible, we have routinely closed these wounds by suture up

to six hours after the receipt of the injury, and frequently as late as twelve hours and always without drainage. The wound surfaces have been covered with a 20 per cent. solution of the oil before the sutures were inserted. Over 75 per cent. of the cases have healed without clinical signs of infections.

There have been 30 cases of extensive burns. The unusual comfort to the patient, together with the simplicity of the dressing, appeals to the patient and surgeon. The time required for healing has been decidedly less than required by any other means employed, and the resulting scars are soft and pliable, and very much better than obtained by us with ambrine.

With Dichloramine-T we have been able to obtain as good results as we have ever had when using the Dakin hypochlorite solutions with the complicated technic of Carrel. In addition, we have found:

1. That skin irritation will not occur if the wounds are not covered with thick occlusive dressings. This means the use of the smallest possible amount of gauze dressing and bandage.

2. The small amount of exudate from wounds treated with Dichloramine, makes it practical to use these thin dressings, and in our dispensary, at the Pennsylvania Hospital, there has been a saving of 75 per cent. of the gauze and bandages formerly used. Further, a still greater saving in dressing material and time results from the decrease in the number of dressings required for each wound during the period of healing. Rarely is it necessary to dress a wound, even during the first few days, more frequently than once in every twenty-four hours, and after that, intervals of forty-eight and seventy-two hours are usual.

3. Dichloramine, unlike the aqueous hypochlorite solution, has no effect upon the knots of catgut ligatures, and no disintegrating effect upon the catgut itself. The occurrence of secondary hemorrhages in wounds treated by the Carrel method was not uncommon in our experience at the American Ambulance. Captain Sweet reports that, in his 1200 cases of major infected military wounds, there was not one secondary hemorrhage.

4. Too great stress cannot be laid upon the value of Dichloramine as a deodorant dressing. The absence of the usual disagreeable odors in our wards, containing cases with fecal fistulæ, is a general observation. During the last two months, it has been used routinely in the wards of the Oncological Hospital in Philadelphia. Where formerly these putrid, sloughing, malignant tissues were irrigated every two hours with all kinds of solutions, with indifferent success in the control of infection and with a persistence of the offensive odor, now they are packed lightly every six hours with gauze saturated with a 5 per cent. solution of Dichloramine-T. Not only has the odor disappeared entirely, but the wound infections have been controlled.

That there may be no misunderstanding of our position as to the value of germicides in the treatment of infections and infected wounds, we wish to repeat the concluding statement of our first report. "One should not depend upon a chemical agent to perform, in the treatment of suppurating wounds, that which can and should be done quickly and thoroughly by mechanical



means. Neither chemistry nor bacteriology can, or should be expected to replace the mechanics of surgery. At the best, these chemical germicides can react only on the bacteria with which they come in contact, which means a very superficial process. Therefore, at the primary operation all foci of infection and all devitalized tissue must be removed when possible, by surgical procedures."

We wish to present in detail the methods used and results obtained in the treatment of infections and infected wounds in the Pennsylvania, Germantown and Children's Hospitals during the last five months—a total of 2213.

Accepting the results of the work of Carrel at Compeigne and Depage at LePan as demonstrating conclusively that infections and infected wounds must be treated with the same surgical asepsis as one follows in the care of sterile wounds, we have tried to consistently make of the primary dressing a formal aseptic operation, with the wearing of sterile gloves and the handling of the tissue with sterile instruments only. We continue this aseptic care of the wound during the entire period of treatment.

In the *preparation of the skin*, soap and water were first used for cleansing, care being taken to plug the wound with sterile oil soaked gauze. Of late we have found that the use of benzine for cleansing the skin is to be decidedly preferred. Neither water, alcohol nor hydrogen peroxide should be used, as they decompose Dichloramine-T.

In *infections* the focus has been excised when mechanically practical, but it has always been widely exposed so that the germicide may have an opportunity for a complete chemical contact with the bacteria. Adequate drainage has always been provided according to accepted surgical principles. After the completion of the mechanical procedures, the wound surfaces are thoroughly covered with the 20 per cent. solution of Dichloramine-T and then the wound edges are held apart by a generous gauze pack saturated with the same strength of oil. A very light gauze dressing is then applied, not more than four layers. If a bed patient, a clothing cradle is placed over the area to avoid displacement of the dressing, which may be held in place by a few strips of adhesive or a towel and safety pins. If the patient be ambulatory, the fewest possible turns of a lightly applied gauze bandage may be used to keep the dressing in place. Care is always taken in applying dressings not to make them impervious, for the solvent, eucalyptol oil, is an essential oil and acts like all essential oils when confined by air-tight dressings. If the discharge is unusual in quantity fresh gauze may be re-applied during the day, but in our experience it is rarely necessary to renew the dressing. The oil should be applied but once in every twenty-four hours. At the first dressing after the operation (and at all subsequent dressings) the same aseptic surgical technic is employed as at the time of the operation; and at this time, primary gauze drainage should be removed and no more re-inserted unless the walls of the cavity or sinus collapse in such a way as to make it impossible to introduce the oil. A 5 per cent.

solution of the oil is all that is required for secondary dressings with the possible exception of massive infections as in carbuncles or extensive bone lesions. Of course an opening in the surface of the wound must be maintained for the introduction of the oil until the infection is controlled. Of the 111 felons treated, it has never been necessary to remove bone or to amputate. During this same period, there have been 37 palmar abscesses and in no case has there been a spread of the infection to the forearm. In this group of 825 cases, amputation because of infection has never been required.

Our first use of the Dichloramine-T for *intra-abdominal infection* was limited to old, well walled-off sinuses following appendicial and tubal abscesses. The unusual rapidity with which these infections were controlled and the absence of any untoward symptoms gave to us the necessary confidence and we now use it routinely at the time of operation in intra-abdominal abscesses in exactly the same manner as described with superficial infections. There have been 13 cases of gangrenous, perforated appendicitis with abscess. Upon the removal of the appendix, the 20 per cent. solution has been dropped over all the visibly infected tissue. A medium sized gauze drain, saturated with the same strength of oil, has then been placed in the cavity and the wound closed in the usual way. The following daily dressings consist in applying 2 or 3 c.c. of the same strength of oil to the gauze wick and upon the edges of the wound. About the fourth day, the drain is loosened and removed when it has separated from the walls of the sinus. This is usually between the third and the seventh day. The cavity is then gently dried by means of gauze or cotton pledgets, and then filled with 5 per cent. oil. It has been our experience that it is rarely necessary to replace gauze drainage after the removal of the primary wick, but of course this may be necessary if the walls of the sinus collapse because of inadequate adhesions. The cavity of the wound is usually filled each day with the 5 per cent. oil until it closes by granulation from the bottom. In none of these cases have there been any unfavorable symptoms; and the average time of complete closure has been 15 days. There have been 9 cases of pelvic abscess of tube ovarian origin in which the oil was applied at the time of operation. Here again there have been no complications and the average time of closing of the wound has been 18 days.

There have been 30 cases of burns. In the treatment of burns it was possible from the start to control the infection with 5 per cent. solution of oil; but the sticky exudate resulting so infiltrated the gauze, that the dressing became adherent and impervious; and a layer of purulent fluid would collect beneath the dressing as with ambrine. We now employ one layer of a wide-meshed paraffined gauze, which is placed over the burned surface and then the oil is sprayed upon this film of paraffined gauze. The open mesh allows the oil to come in contact with the wound surface and also for the wound exudate to escape. No other dressing should be applied and the usual technic of the open-air treatment of burns should be followed.

## DICHLORAMINE-T IN WOUNDS

Depending upon the amount of exudate, the paraffined dressing can be painlessly removed daily or less frequently as required.

For the preparation of an open-meshed gauze to be used in the treatment of burns we have found the following method of preparation the most satisfactory:

Ordinary mosquito netting of good quality with a mesh of about one thirty-second inch is cut in strips on the thread six inches wide and one yard long. It has a small amount of starch or stiffening in it which it is not necessary to wash out, in fact it can be handled and rolled more easily if this starch is not removed.

The ambrine, parawax, redintol J. & J. or cerelene, or similar preparation is melted on a water-bath in a flat tray and brought to the boiling point. When it is thoroughly melted one end of the strip of mosquito netting is folded over a glass rod as in starting a roller bandage. This is dipped in the melted wax and with the tips of the fingers protected by rubber gloves grasping the ends of the glass rod it is rolled up, letting the strip of mosquito net run through the melted wax as it is pulled towards the roll and the roll is wound up slowly as it rests on the bottom of the pan. When the strip is all rolled up, continue turning the roll over and over in the melted wax until it is thoroughly soaked, then quickly stand it on end in the pan of hot melted wax. The wax on the gauze quickly drains out of the meshes as it remains in the heat; the little excess that remains on the end of the roll can be shaken off. Allow the roll to cool slowly by standing it on end. Store in a sterile muslin container.

We have tested several combinations of paraffine and petrolatum, paraffine and liquid petrol, paraffine and beeswax, and plain beeswax—as to their solubility by Dichloramine-T in eucalyptol oil. In all combinations where petrolatum or liquid petrol or beeswax was used to make the paraffine flexible, these substances were dissolved out of the wax and made the dressing soft and rendered the paraffine thin and friable on the gauze. Pure paraffine, redintol and cerelene were unaffected by prolonged soaking in Dichloramine.

*Wounds.*—(a) *Incised Wounds.*—Employing the same aseptic technic previously described, all bleeding vessels are ligated with catgut; the wound surfaces covered with the 20 per cent. solution of oil and then the edges closed with sutures and without drainage. We strongly advise against the use of drainage of any kind in the primary suture of wounds; it is unnecessary when employing Dichloramine-T and always provides a definite focus of infection. Dichloramine-T does not affect the tensile strength or the holding of the knots of catgut after an exposure of more than three weeks, so that the danger of secondary hemorrhage from the slipping or premature absorption of ligatures can be disregarded. The capillary ooze in the presence of Dichloramine-T and eucalyptol oil is decidedly less than with any other germicide we have used; and there will be no more oozing than the tissues are normally able to care for, while you have placed in the tissues a mass of germicide that makes infection very improbable. Thus the two

indications for draining incised wounds, hemorrhage and infection, are almost entirely eliminated when Dichloramine-T is used. In the subsequent dressings, the surfaces and wound edges may be sprayed daily, or even less frequently, with a 5 per cent. solution of oil until the wound is dry. If infections develop, it is only necessary to remove one or two stitches, to obtain a small opening through which the solution may be introduced into the depths of the wound. For us, the simplest method has consisted in the introduction of a grooved director through such an opening, to the bottom of the wound; and then when the coarse spray of an atomizer is directed against the groove, the oil flows into the wound. This also may be done with a glass hypodermic syringe and needle. It has been our experience that infection has been controlled on an average of  $5\frac{1}{2}$  days, when developing after the primary suture of incised wounds.

*Wounds.—(b) Lacerated Wounds.*—After the usual preparation of the skin, all the devitalized tissue is removed with a knife, scissors and forceps, that it is mechanically practical to take away; and in a like manner all foreign bodies and splinters of bone (if they be detached from the periosteum). If the primary operation takes place within three hours after the injury, the wound should be closed by suture after thoroughly covering the wound's surfaces with the 20 per cent. solution of the oil without drainage. When infection subsequently develops the previously described technic is followed, just enough of the stitches being removed to allow the introduction of the oil to the focus of the infection.

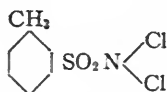
*Wounds.—(c) Crushed.*—When these involve the hands and feet, the treatment and results are not very different from the lacerated wounds. The time of healing, of course, is increased, tendons require more time than subcutaneous tissues; bone more than tendons; while the longest time required for healing is when there is joint involvement. We have had 10 compound fractures of the leg but none of the thigh. The treatment of these compound fractures, when involving these small bones, should be along the same lines described in the care of lacerated wounds. We have successfully closed one compound fracture of the tibia and fibula on the seventh day; and we have successfully closed a large compound fracture of the tibia and fibula with a 5-inch wound in the overlying soft tissue by primary suture six hours after the accident occurred. The question of secondary suture, which has not entered into the problem of the care of the incised, punctured, perforated and lacerated wounds, because of the rapidity with which they have closed of themselves, of course, enters into the problem of the care of the massive wounds, as compound fractures of the long bones. Our study of the bacterial counts of the wound has demonstrated that it is possible to bring the count to the point of clinical sterility, one bacterium per five microscopic fields, for three successive days, just as promptly as with hypochlorite.

*Wounds.—(d) Massive.*—In which it is mechanically impossible or surgically undesirable to close by sutures. Here the primary operation in no way differs from that of the treatment of lacerated wounds, except in

## DICHLORAMINE-T IN WOUNDS

degree. In these wounds the question of dependent drainage is always to be considered, and provided, if surgically indicated. At the completion of the operation the surfaces of the wound are thoroughly covered with a 20 per cent. solution of oil and then wide-meshed paraffined gauze strips are placed directly in contact with the raw surfaces of the wounds to make the subsequent removal of the dressings painless. Over the paraffined gauze not more than 4 layers of gauze should be placed.

Dichloramine-T is prepared from toluol by a series of chemical reactions which lead to a substance having the following structural formula:



Its use as a disinfectant is dependent almost wholly on the reactions of the  $\text{NCl}_2$  group in the side chain. In this group the chlorine (Cl) is very loosely held and is given off whenever the substance comes in contact with any other material having an affinity for chlorine. When detached from this compound chlorine it is in the free or nascent state and exerts all of its characteristic elementary reactions.

Free chlorine unites with nearly all common substances and materials to form chlorine compounds which are as a rule less stable than those substances from which they came. The well known action of bleaching powder depends upon this fact. It is the chlorine in the bleach which attacks the colored substances in cloth, forming chlorine compounds with them. These chlorine compounds are subsequently destroyed by the oxygen of the air or other agencies. The union of chlorine with other substances is greatly hastened by the presence of water or the moisture of the air, by the action of light, particularly direct sunlight, and by heat.

To return to Dichloramine-T; this substance is almost insoluble in water. It is soluble in a considerable number of organic solvents and oils. It is soluble, for example, in benzol, chloroform, carbon tetrachloride, alcohol and acetone. It is soluble in many essential oils, eucalyptol among them. Those solutions in which the solvent cannot be attacked by chlorine are stable. The compound carbon tetrachloride contains all the chlorine it is capable of taking up—it is saturated with chlorine, and therefore Dichloramine-T in such solution is stable. Alcohol on the other hand is broken down by free chlorine, it rapidly abstracts chlorine from the Dichloramine-T and is itself changed to other substances and the alcoholic solution of Dichloramine-T keeps but a very short time.

For the purpose of applying it to wounds the Dichloramine-T must be in solution. Carbon tetrachloride or chloroform would be good solvents because of the stability of the solutions, but are not suitable to apply to living tissues in quantity for a long time. Eucalyptol has been chosen after a very careful search as the best available solvent to use for the application of Dichloramine to the tissues.

Eucalyptol has, however, an affinity for chlorine such that it quickly

breaks down the Dichloramine-T. This makes it impossible to use it directly. Eucalyptol can be first treated with chlorine and its affinities are thus partly saturated. This chlorinated eucalyptol is a good solvent for Dichloramine-T. Its chlorine affinities cannot be completely satisfied, however, and the stability of the solution is far from perfect. Dissolved in chlorinated eucalyptol, Dichloramine-T is slowly broken down, that is, the chlorine is given off and the toluol-sulphon-amid (an intermediate product between toluol and Dichloramine-T) is left. This substance crystallizes out. The chlorine given off is partly set free into the air and partly acts further on the eucalyptol to produce irritating volatile products. The decomposed solutions frequently cause much irritating pain when applied to wounds.

The breaking up of Dichloramine-T in chlorinated eucalyptol is hastened by the presence of water, alcohol, or anything else that has an affinity for chlorine. The chlorinated eucalyptol is capable of taking up a certain amount of water from the air. The breakdown is hastened by the action of light and by any rise in temperature.

For the foregoing reasons particular attention must be paid to the following points in handling Dichloramine-T and its solutions:

1. All bottles should be of a dark amber, glass stoppered. They should be thoroughly cleaned and dried before any of the materials are put in. If alcohol is used for drying the bottles, it should be allowed to completely evaporate before the bottles are used.

2. No solutions should be returned to the stock bottles from the ward bottles or atomizers at any time.

3. Bottles in which the solution has already undergone decomposition should be very carefully cleaned with hot water and then dried thoroughly before being used again.

4. If, in using the 20 per cent. solution, medicine droppers or glass rods are used to transfer the oil to the wound surfaces the droppers should be dry if put into the oil bottles. The common practice in some places has been to boil these utensils to sterilize them and then to use them while still wet. This results in the gradual accumulation of water in the stock bottles and a very rapid decomposition of the Dichloramine-T. The glass rods or pipettes or syringes if left in contact with the oil for five or ten minutes are entirely sterilized and do not need boiling. The method we have followed is to pour the required amount for the wound into a clean dry medicine glass and to take the oil with the pipette from this second container.

If these precautions are faithfully observed, no trouble from the decomposition of the solution will be encountered. We have repeatedly kept the 20 per cent. solution on the laboratory desk in brown bottles for three to four weeks before it decomposed.

## BIRTH INJURIES OF THE SHOULDER\*

By ASTLEY P. C. ASHHURST, M.D.

OF PHILADELPHIA

THE clinical entity known as brachial birth palsy has been the subject of a number of rather controversial papers in recent years. These controversies have had to do both with the pathogenesis of the affection and with its treatment. The present contribution to this discussion is based on a careful study of about forty patients seen within the last few years in my services at the Episcopal and Orthopædic Hospitals, and is an effort to systematize the treatment of a condition still too frequently overlooked by the average practitioner, or, even if not overlooked, too often neglected. It is difficult to systematize the treatment of an affection whose pathogenesis is not known; but in spite of much study I must confess that my views on the latter subject are still uncrystallized. But I know that much good may be accomplished by definite lines of treatment and much harm done by neglect or by misdirected efforts. This is, in fact, one of those departments of surgery in which Science still lags behind Art; but as experience accumulates there is every reason to believe that Art, like Wisdom, will be justified of her children.

First brought prominently before the profession in 1872 by Duchenne, it was an affection long regarded as of interest solely to neurologists, owing to the prevalent theory as to its causation: Duchenne taught that the lesion was in the brachial plexus, but as his observations are recorded in a text-book devoted to Local Electric Treatment he did not enter into the question of exact anatomical localization of the lesions. Erb, in 1874, studied the similar but much rarer affection in adults, and specified more particularly that the lesion occurred at the junction of the fifth and sixth cervical roots of the brachial plexus. He thought it was due to direct pressure at this point ("Erb's point"). The teachings of Duchenne and Erb have dominated the minds of medical men until within recent years. It is true that Küstner, in 1889, stated that all such cases seen by him really were instances of separation of the upper epiphysis of the humerus; but his views were not accepted by others. Moreover, Whitman, in 1905, in a brief paper which seems to have been completely ignored until recent years, called particular attention to posterior dislocations of the shoulder often associated with this condition, and urged rational treatment of the dislocation when present on the plan adopted in cases of congenital dislocation of the hip. He expressed the belief that true congenital dislocation of the shoulder was exceedingly rare, as was also a dislocation due to injury during birth; holding that the posterior dislocations so often accompanying brachial birth palsy were the result of the paralysis, not of the birth injury. A. S. Taylor, still upholding

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\* Read before the Philadelphia Academy of Surgery, October 1, 1917.

the purely neurogenous theory, reported in 1907 a series of cases in which operation had been done by him on the brachial plexus, and referred to some experiments by himself (1905) tending to show that it was possible for the roots of the plexus to be ruptured by traumatism (see paper by Clark, Taylor and Prout).

Meanwhile, general surgeons had been studying cases of the similar lesions seen in adults, to which Erb at first called special attention. Duval and Quillain, in 1898, as a result of their studies, came to the conclusion that there were no such clinical entities as paralyses due to lesions of the brachial plexus, only two types existing, *radicular* and *terminal*, affecting either the spinal motor roots or the nerve-trunks below the plexus. Subsequent observations appear to have confirmed these conclusions, both as regards the injuries occurring at birth and those encountered during adult life. Delbet and Cauchoux in 1910 collected 36 cases of paralyses complicating dislocations of the shoulder: 25 of these were *terminal* paralyses, and were the sole lesions produced by the dislocation itself; the remaining 11 lesions all were *radicular* and were due not to the dislocation, but to the cause which produced the dislocation. There were no true lesions of the brachial plexus in this series.

Now T. Turner Thomas, who had been studying the "stiff and painful shoulders" for which Codman and others have erected a pathology based on so-called subdeltoid bursitis, turned his attention to the pseudoparalyses often, if not indeed usually, present in these cases, and at a meeting of the Philadelphia Academy of Surgery in October, 1910, proposed the theory, to which he has steadfastly adhered, that in almost all such cases, birth injuries or adult injuries, the supposed paralyses are secondary to a primary lesion of the capsule of the shoulder-joint; that the effused blood, lymph and synovial fluid catch the nerves in cicatricial tissue; and that the dislocation so frequently accompanying the birth injuries is primary, and therefore the cause, not the result, of the brachial palsy. Similar teachings were subsequently (June, 1912) promulgated by Lange; but neither Lange nor Thomas has been able to secure general recognition of the truth of their doctrines.

Sever and J. J. Thomas (1916) have recently published two studies based on 470 cases of brachial birth palsy, personally observed by one or both of them. Sever refers to his "numerous dissections on infantile cadavers" which showed that "traction and forcible separation of the head and shoulder puts the upper cords, the fifth and sixth cervical roots of the brachial plexus, under dangerous tension." This confirms Taylor's experiments of eleven years previously, and it may perhaps be accepted as proved that such a lesion can occur during obstetrical delivery by a similar mechanism.<sup>1</sup> The theory of direct pressure on the plexus as a cause has been abandoned. In his experiments Sever was unable to rupture the joint capsule, to separate

<sup>1</sup> However, it may well be, as suggested in a personal communication by T. T. Thomas, that the preservative fluid makes the brachial plexus of infantile cadavers more prone to laceration than is the plexus in the normal baby at birth.



the epiphysis, or to dislocate the head of the humerus. He notes, however, that in 1900 Stone had been able easily to separate the epiphysis; and T. T. Thomas says (*loc. cit.*, 1914, p. 212) that he has in several infant cadavers obtained by hyperabduction an epiphysial separation or a fracture of the upper end of the humerus, but the capsule was stronger than the humerus, as suggested by Lange. But the contention of Thomas is that rupture of the capsule is produced not by hyperabduction (which, as already noted, produces epiphysial separation or fracture) but by direct pressure on the humerus and acromion by the maternal pelvis, the arms being flexed and adducted at the shoulder (*loc. cit.*, 1914, p. 212).

As a result of these divergent views of the pathogenesis of the condition, there has been equally great divergence in the methods of treatment recommended; and until within the past ten years no very active treatment of any kind has been instituted even by neurological or orthopædic surgeons. My own active interest in the condition was aroused not much more than five years ago, by the apparently increased frequency with which patients of this type were being seen, and the consequent necessity of systematizing their treatment. My views of the pathogenesis were briefly expressed in discussing the views of Thomas already noted (*Trans. Phila. Acad. Surg.*, 1914, xvi, 235; *ANNALS OF SURGERY*, 1914, lix, 142). These views I still hold:

"First, that pure nerve lesions occur, and may be of much greater importance than any injury to the shoulder-joint even if this is present; and, second, that posterior subluxation of the humerus is a frequent lesion, often overlooked, and perhaps may be the cause of persistence of paralysis." Dr. Thomas, in reply, said "that he did not mean to say that none of these cases of birth palsy were due to rupture of the brachial plexus, but he believed that none of his twelve cases were. He thought it fair to say that most cases are not."

Formerly, babies with "birth palsy" which came under my notice at the Orthopædic Hospital, in the services of my chiefs, G. G. Davis and R. H. Harte, usually were referred to the Nervous Department of the Hospital, and seldom or never returned for observation by the surgeons. I remember asking the neurologists what became of such patients in adult life; and the consensus of opinion seemed to be that they all recovered without disability, as none of the neurologists whom I questioned had ever seen an adult who had had "birth palsy." I remember also that occasionally when these babies were brought to us at a very early age and the shoulder seemed particularly painful, the diagnosis made was epiphysial separation of the upper end of the humerus; then they were retained under surgical care, the arm bandaged to the side or in a sling, until acute symptoms subsided, and, after being referred to the mechanotherapeutic department for massage, were again lost to sight. I remember only one case diagnosed as "congenital dislocation of the shoulder"; this was in a boy of seven years or thereabout, with a subspinous dislocation of the left shoulder, and with the history that it had been present from birth. There was no question of the presence of the dis-

location; and though the question of the etiology (whether truly a congenital deformity, or from trauma during parturition) was discussed, no satisfactory conclusion was reached, and as no active treatment was urged, the patient did not return. There was only slight disability and no apparent paralysis.

When I began to pay particular attention to these patients, stimulated largely by conversations with G. G. Davis and T. T. Thomas, it did not take very long to learn that the reason they had ceased to be brought to the clinic was not because no disability remained (though this was the case in a few) but because the parents were led to believe the condition was hopeless and that nothing more could be done.

It is the contention of the neurologists that the lesion occurs in most cases at the junction of the fifth and sixth cervical roots as they join to form the upper cord of the brachial plexus. This point is just above the origin of the suprascapular nerve supplying the external rotators of the shoulder; and it is these muscles which are most constantly paralyzed. They point out, moreover, that from the fifth and sixth roots comes also the musculocutaneous nerve, supplying the flexors of the elbow (biceps and brachialis anticus); while the axillary (circumflex) nerve supplying the deltoid (usually also paralyzed) comes almost entirely from the fifth cervical. But they conveniently ignore, or seek to explain by plausible arguments, contrary facts, such as that the very same nerve roots transmit fibres for the subscapularis muscle, the pectoralis major, the latissimus dorsi, the teres major, and the pronator radii teres muscles, none of which, as a rule, exhibit any lasting paralysis, if indeed they were not intact from the very moment of the injury. A. S. Taylor, Fairbank, Sever, and others, all acknowledge the truth of the common teaching that the subscapularis is supplied by fibres derived solely from the fifth and sixth cervical, and yet it is never found paralyzed. Fairbank alone boldly faces the dilemma, and, though he admits freely that this muscle by its contraction is responsible for the posterior subluxation of the shoulder, being unopposed by the paralyzed external rotators, puts forth this explanation: that "recovery of the nerves has taken place before this deformity has occurred or at any rate become fixed, and in cases in which the paralysis is permanent the subluxation does not occur." This is clearly an untenable theory: if recovery of the nerves to the subscapularis occurs with such regularity, why does not recovery of the nerves to the other muscles also occur, if the lesion has been where all the fibres pass in a common trunk? Moreover it is simply not true that posterior luxation does not occur when the paralysis is permanent; witness my Case V. Unless, indeed, he means that posterior luxation does not occur if the subscapularis remains paralyzed; but I do not know of any cases reported in which paralysis of this muscle has been observed. A. S. Taylor seems to have had but a confused idea of the effect of these paralyses: he refers to the deformity which develops from *contractures of the paralyzed muscles and the ligaments of the joints*. Thus he assumes that *contracture* of the subscapularis occurs because it was paralyzed (of which there is no

## BIRTH INJURIES OF THE SHOULDER

evidence), but he attributes *relaxation* of the external rotator muscles to their paralysis, and yet considers the limitation of elbow extension due to *contractures* of the paralyzed flexor muscles. It is despair over a theory such as this, which blows hot and cold out of the same mouth, that encourages others than neurological surgeons to look elsewhere for an explanation of the phenomena encountered in this still obscure condition.

Unless the anatomy commonly known is incorrect, I do not see how the immunity of certain muscles, especially of the subscapularis and teres major, can be explained, if the nerve lesion is supposed to be at the juncture of the fifth and sixth roots. The descriptions of what has been found at operation soon after birth are so vague that not much reliance can be placed on such observations; this vagueness probably is due to the impossibility of telling, even with the nerves exposed to view, how much they were damaged. In cases operated on months or years after the injury occurred, the extent of the scar tissue and the difficulty of the dissections render such observations also of limited value. It may well be, as indicated by some of these operations, that the suprascapular nerve itself (below the plexus) is damaged at the time of the original injury. Indeed it has occurred to me that it may be not improbable that all the nerve lesions in the majority of these cases are *terminal* and not *radicular*. Consider the course of the nerve-trunks (terminal) which supply the various groups of muscles: *all the muscles most constantly paralyzed are supplied by nerves which pass very close to the shoulder-joint*<sup>2</sup> and *ipso facto* are liable to injury; whereas *the muscles which habitually escape paralysis are supplied by nerves which at no part of their course come into close relation with the shoulder-joint or the bones which compose it*.<sup>3</sup>

This seems to bring us very close to the theory of Thomas and Lange, that the primary lesion is in the shoulder-joint, and that involvement of the nerves occurs secondarily. It is indeed a question in my own mind whether this is not the most acceptable theory for the majority of cases; but as already stated, I do believe that radicular lesions of the nerves occur, though in a comparatively small proportion of the total number of cases of birth injury.

When lesions in nerves occur by overstretching, it is accepted that rupture of the sheaths occurs first, permitting hemorrhage among the nerve fibres; eventually, if traction is continued, partial or complete rupture of the nerves themselves occurs. Any degree of injury, trifling or complete, may occur in this way; and it is a matter of common experience that in almost all cases of birth injury a remarkable improvement occurs without any operation, if proper non-operative treatment (massage and passive movements to prevent contractures) is begun soon after birth (Case I). Hence it is safe to assume,

<sup>2</sup>These include the suprascapular (most often injured), musculocutaneous, and the circumflex; the musculospiral also is frequently injured.

<sup>3</sup>These include the subscapular nerves, the median and ulnar nerves, the anterior thoracic nerves (to the pectorals), and the nerves to the rhomboids and to the serratus magnus.

in the majority of cases, that the nerve lesion, wherever and whatever it is, is not very extensive, and that in such cases no operation on the nerves is advisable. But there are cases, few in number, in which to my mind the evidence of extensive nerve lesion is undoubted (Cases IV, V, VIII, X, and XIII); Sharpe speaks as if he had had experience with this class of patients alone, and at least it is to be hoped that he is not subjecting all the milder cases to exploratory operation on the nerves. He says he has operated on 56 patients in all. Unfortunately none of his cases are reported in detail, and it is impossible to judge how much improvement has been secured, and especially whether any greater improvement has been secured than may be obtained by non-operative means. Most of his operations probably were too recent for end-results to be available; but until he can show better end-results than are being secured by others without operation on the plexus, he cannot expect his views to have great influence. His chief argument in favor of early operation appears to be that even if it proves useless it will be harmless. He acknowledges that it is usually impossible to tell without direct inspection of the nerves whether or not they are seriously damaged; but he contends that it is more to the patient's interest to have an exploratory inspection of the nerves than to wait until it may be determined clinically whether or not serious nerve damage is present. In cases of apparent "total paralysis" he urges operation at the age of one month; half of those patients so treated, he says, have shown marked improvement. But it is equally true that at least half, if not more, of such patients treated without early operation also show marked improvement; it is true they do not recover nearly as good function as do those patients in whom soon after birth the apparent paralysis was not total. Those infants he has operated on at the age of three months have shown more constant improvement, because, he claims, the paralysis was less severe at first; but he believes a still greater improvement would have occurred if operation had been done at the age of one month; and he seems to urge this early resort to operation in *all* cases in the future. Older patients, he says, give the worst results. In opposition to operative measures to lessen the mechanical disability of the patient (by reducing the dislocation, if present, by tenotomies of shortened muscles, etc.) he states: "I have yet to see cured by this method of treatment one case of brachial plexus paralysis in which at birth there was total paralysis of the arm, hand and fingers." Improvement, he admits, may occur even without any treatment, but he thinks it rarely continues beyond one year of age, and a useful arm is never obtained. If he really limits his remarks to cases of "total paralysis," probably all will agree with him, but will point out that no such cases have been "cured" by neurological surgery.

As regards *treatment*, then, I reject nerve operations in early infancy. Babies are seldom if ever seen for the shoulder injury until they have reached the age of three or four weeks. At this time they either have or have not a demonstrable dislocation.

In case *no dislocation is present*, I believe the proper treatment consists,

as pointed out by G. G. Davis, in keeping the hand and arm in front of the body (so as to prevent extension of the elbow and excessive internal rotation of the shoulder) by putting the arm in a sling or by pinning the sleeve to the front of the dress. In addition, as soon as the soreness of the birth injury permits, passive motions should be instituted, especially external rotation and abduction of the shoulder, to prevent shortening of the subscapularis and anterior capsule. Massage also is of value, and above all the child should be encouraged to make active movements of the kind indicated above. Electricity certainly has some value, at least in children of the age of six months or older. I think its value in early infancy is open to question. If these patients are treated in this way from the time of birth, most will recover with little permanent disability. In a few such patients, and in most of those seen for the first time a number of months after birth (especially if dislocation of the shoulder is present), additional measures will be necessary as detailed below.

In case *dislocation is present*: In some patients there can be no doubt that the dislocation was present at birth; but it is a question whether there are any examples of dislocations of the shoulder which were present *in utero*, i.e., truly "congenital" dislocations.<sup>4</sup>

It is possible in some babies seen very soon after birth that proper treatment as above indicated will secure reduction of the dislocation by passive motions (Case IV). But in all cases where the dislocation is at all pronounced, I think it is advisable to anæsthetize the child at about the age of six months, and to reduce the dislocation bloodlessly in a manner analogous to that employed by G. G. Davis in treating congenital dislocations of the hip: the baby is placed prone on a well-padded orthopædic table, with the affected extremity hanging over the side of the table. Owing to the internal rotation of the humerus the arm will not hang vertically downward, but will point toward the patient's feet. First, this internal rotation should be overcome by very gently but persistently rotating the humerus outward by means of the flexed forearm. When the forearm has been brought thus into the horizontal plane (the coronal plane of the patient's body) direct downward pressure should be made on the head of the humerus, which usually will be felt to jump forward into normal relation with the glenoid process. Reproducing the dislo-

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<sup>4</sup>I do not know how to explain the conditions encountered in Case IV. It is difficult to explain the persistency with which the arm rebounded to the highly abnormal position in which it was found at birth unless we admit that this position had been long maintained *in utero*. Though the labor in this case was difficult ("version was attempted"), it might be that the difficult labor was caused by the malposition of the arm *in utero*, not that the labor produced this malposition. Certainly in all ordinary recent traumatic dislocations, when the dislocation is reduced the deformity does not recur immediately, as it did in this patient during a period of from three to four months after birth. However, in this patient there is no reasonable doubt that there was injury in birth, since even as late as May, 1917, when the child was in her fifth year, considerable paralysis remained, the hand being almost useless, though the shoulder and elbow were normal.

cation and again reducing the head several times will leave no doubt in the mind of the operator or assistants that proper reduction has been secured. When the head of the humerus has thus been forced out onto the glenoid eminence, it will be found that the elbow can no longer be fully extended, owing to the shortening of the flexor muscles (long and short heads of the biceps and the coracobrachialis). This is analogous to the shortening of the hamstrings produced by reduction of a congenital dislocation of the hip. As in the case of the hip, so also at the shoulder, the head of the dislocated bone may be palpated anteriorly so soon as reduction is secured. It still remains to secure abduction of the shoulder-joint. This is most safely done by moving the child away from the edge of the table, so that the arm no longer hangs over the side of the table but lies upon it. With the flexed elbow lying upon the surface of the table, and the child's chest flat on the table, it will be observed that the shoulder is kept some distance above the table, by the tension of the anterior capsule and subscapularis muscle. Intermittent downward pressure is then made upon the posterior surface of the shoulder until its anterior surface comes into contact with the surface of the table. Then the elbow (still flexed) is very gradually raised from the table, by placing beneath it first one, then two, and later three or four folded towels, while intermittent downward pressure is made on the posterior surface of the shoulder. This process should be continued until the elbow lies well posterior to the frontal plane of the patient's body. There will now be little tendency for the dislocation to recur, and the entire upper extremity and chest are to be encased in plaster-of-Paris to maintain this position. This gypsum case should be retained for six weeks, when it should be renewed, with the arm in the same position; the second case should not be removed for six weeks more, thus maintaining reduction in the overcorrected position for a period of three months. If a shorter period of overcorrection is permitted, the dislocation tends to recur, especially in older patients. I have found that after the age of four years bloodless reduction is not efficient. It does more damage to the structures of the joint, and accomplishes less than bloody reduction by arthrotomy.

In patients over four years of age I recommend the following method for reduction of the dislocation:

A curved incision is made, as advised by Senn, around the acromion and about 3 to 4 cm. distant from it, from the coracoid process in front to the spine of the scapula behind (Fig. 1). This incision is deepened until the deltoid is exposed, and the skin and fascia are then turned upward as a flap, thoroughly exposing the acromion and the acromioclavicular joint. An incision is then made through the fascia and periosteum covering the spine of the scapula, and this spine is bared by stripping the periosteum from it until a guide can be passed under the base of the acromion, to protect the suprascapular nerve and vessels (Fig. 2). The acromion is then osteotomized obliquely at its base, the acromioclavicular joint is opened, and the acromion is turned forward, carrying with it the deltoid (modification of Kocher's

method for excision of the shoulder). This thoroughly exposes the upper aspect of the shoulder-joint (Fig. 3). The long tendon of the biceps is identified; on its median or anterior border lies the lesser tuberosity, while laterally or posteriorly lies the greater tuberosity.<sup>5</sup> To secure normal external rotation of the shoulder, the insertion of the subscapularis is now divided while kept under tension by an assistant endeavoring to rotate the humerus outward. At once reduction of the posterior dislocation becomes possible without difficulty, and usually abduction also now becomes free; but if it is still resisted it may be necessary to divide or lengthen the tendon of the pectoralis major through a separate incision. Next, while the humerus is maintained in full external rotation and abduction, the tendons of the supraspinatus and infraspinatus and teres minor muscles, as they insert into the greater tuberosity, are plicated by mattress sutures of chromic gut, thus shortening them, and maintaining the head of the humerus in its forward and externally rotated position. The acromion is now replaced. In some cases it is so much deformed that it will no longer fit in its former position, as the place its tip formerly occupied is now held by the reduced head of the humerus. It is then necessary to remove a section from the sawn surface of the acromion, in order to raise its tip out of the way of the shoulder-joint (Case X). The acromion in younger patients is largely cartilaginous and may be held in place by sutures of chromic gut including the overlying periosteum, fascia and muscles, as well as the bone; but in older patients screw fixation is preferable. The skin flap is then replaced, and sutured without drainage, the arm being constantly maintained in the "light-house position." The plaster-of-Paris dressing is not to be changed for six weeks, when a new similar fixed dressing is applied for a second period of six weeks.

After removal of the dressings it is important to resume active and passive movements, especially to encourage external rotation, abduction and supination. I have adopted this operation in five cases, with no recurrence in any patient, and marked improvement in all (Cases V, VI, VII, VIII and X).

Even in older patients where no dislocation is present, very great disability may be caused merely by muscular contractures, and this may be relieved much more rapidly and efficiently by operative means than by prolonged courses of passive movements and gymnastics. The greatest disability in all these cases usually is due to *loss of supination* and to *loss of external rotation at the shoulder*. Even when all the muscles are strong and active, the children cannot get their hands to their mouth without abducting the humerus (owing to the fixed internal rotation), and in many cases they cannot get their hands to their mouths at all, even in the position of pronation.

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<sup>5</sup> In several cases I have found the bicipital groove located directly in the line of the external condyle, owing to excessive internal rotation of the shaft of the humerus below the tuberosities, presumably due to the unopposed action of the unparalyzed pectoralis major and teres major muscles. Hoffa, it should be recalled, treated some of his patients by osteotomy of the shaft of the humerus about its centre, rotating the lower fragment outward. This, however, does not overcome the chief cause of disability, namely, the internal rotation at the shoulder-joint, where the subscapularis is tense.

Treatment by a series of plaster cases, endeavoring to overcome the contractures gradually, as in some contractures of tuberculous joints, has also been tried in my clinics, but has not been found so efficient as the cutting operation. For this purpose an anterior incision is made, as for excision of the shoulder, passing through the anterior fibres of the deltoid; the long tendon of the biceps is identified, and then the lesser tuberosity, where section is made of the tendon of the subscapularis. If contracture of the pectoralis major prevents full abduction, its tendon may be lengthened by Z-plasty or may be completely divided, through a prolongation downward of the same incision. I have not observed any disability to follow complete section of the tendon of this muscle, and believe it is simpler and therefore preferable to a formal lengthening operation.<sup>6</sup> I have employed this operation for birth injury of the shoulder in two cases (Cases XI and XII), and my assistant, Dr. A. Bruce Gill, has also adopted it with satisfaction.

In one case in the present series the disability at the shoulder arose chiefly from the paralysis of the deltoid; this was entirely relieved by transplantation of the pectoralis major to supplant the deltoid (Case XIII). In this same patient there was great disability as well from the residual paralysis in the forearm; function was materially improved by tendon transplantations.

In a fair proportion of patients with birth injury at the shoulder, who have not received adequate treatment soon after birth, considerable disability persists from deformity at the elbow. It is possible that the elbow is injured at the time of birth, but I am inclined to believe that the main deformity is gradually developed as the result of the malposition in which the elbow is held. The forearm is kept in full pronation, the elbow slightly flexed, and the whole limb internally rotated. The head of the radius gradually grows upward past the external condyle, and when seen in adolescence the patient may present a complete posterior dislocation of the head of the radius, as in Case X of the present series. All grades of subluxation may be present. It is known that in cases of hereditary deforming chondrodysplasia posterior dislocation of the radius is not unusual, owing to the lack of equal growth of the ulna; and it may be that disuse of the forearm and use of the hand (which is the usual state of function in patients with birth injury of the shoulder) tend to produce lack of development of the ulna (which is an elbow and forearm bone) and full development or even overdevelopment of the radius (which belongs rather to the wrist and hand than to the elbow or forearm).

The case histories which follow have been selected to illustrate the prognosis and treatment of certain types of the affection:

(1) The usual mild case, recovering nearly perfect function under treatment by massage, passive and active movements, etc. (Case I).

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<sup>6</sup> Fairbank in 1913 described an operation similar to this, and Sever has lately described a modification of it as an original procedure; his modifications consist in making the incision in the deltopectoral groove (where the cephalic vein is in the way), and in dividing the tendon of the subscapularis on a grooved director.



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(2) The same type of case, but complicated by posterior dislocation of the humerus (Cases II and III).

(3) The severe type, in which the residual paralysis causes far more disability than could any dislocation (Cases IV and V).

(4) The typical case of subspinous dislocation coming under treatment late, and with no disability except that due to the joint deformity (Case VI).

(5) The typical case of subspinous dislocation with moderate paralytic disability (Cases VII, VIII, IX, and X).

(6) The typical case of disability from contractures without either dislocation or paralysis (Cases XI and XII).

(7) The unusual type of flail shoulder (Case XIII).

The frequency of subspinous dislocation in the patients under my care is worth noting; it was present in more than 40 per cent.

Another feature which I think bears emphasis is the frequency with which two or more children in the same family are affected: in one instance three sisters were similarly injured in birth, and the fourth child was killed during delivery. In several other instances brothers or sisters have died at or soon after birth from injury; in one case (Case VI) 5 other children were killed at birth. There is room here for improvement in obstetrics.

*CASE I.—Birth injury of the right shoulder without dislocation; recovery under treatment by massage and active and passive movements.* Mollie R. was brought to the Orthopædic Hospital October 10, 1914, at the age of ten weeks. It had been a footling presentation, easy labor of four hours' duration, no instruments being used. There was one older child, now three years old.

*Examination.*—The right shoulder is held quietly by the side, in internal rotation. She makes no attempt to move the shoulder, but she moves the fingers slightly. No dislocation is present. The electrical report by Dr. Cadwalader shows that the deltoid does not react to Faradism, and Galvanic current causes too much pain to be used.

*Treatment.*—Massage and passive motions, three times weekly.

November 26: Has fair grasp in hand, uses arm a little. It can be passively raised above head and placed behind back. External rotation is limited a little within the sagittal plane.

January 9, 1915: External rotation is possible beyond the sagittal plane.

February 13: Nearly seven months old. Dr. Cadwalader reports: probably complete reaction of degeneration in the deltoid; no reactions of degeneration in other muscles.

June, 1915: Uses hand and arm all the time.

August, 1915: No dislocation has developed. Fair power has returned in the deltoid.

December, 1915: Puts hand to mouth in semisupination, and with shoulder slightly abducted. Scarcely any limitation of passive external rotation or abduction.

July, 1916: Can raise right arm above head almost as well as left arm. Puts hand to mouth and top of head easily, and can be placed behind back passively with ease.

October, 1916: Right arm almost normal. Dismissed from further treatment at the age of twenty-six months.

CASE II.—*Subspinous dislocation of right humerus; bloodless reduction at age of six months.* William A. F. was first seen at the Orthopædic Hospital November 6, 1913, at the age of three months. He had one sister, six years old, who was normal. This boy had been injured in birth which was not instrumental (L. O. A.) There had been a cephalhæmatoma at birth, over the right parietal, and this region was still palpably thickened up to the age of four months. He held his right arm at the side, in internal rotation, and all shoulder motions were limited, especially abduction. He has pain when the arm is moved. The hand, fingers and wrist are kept flexed, and the hand is in ulnar adduction. There is good power in the triceps, and a good grip in the hand, but no power of flexion of the elbow. The head of the humerus was palpable beneath the spine of the scapula, and a skiagraph (Fig. 4) showed the epiphysial centre for the head of the humerus not opposite the glenoid as on the normal side, but luxated out and up. As the child was brought from out of the city, the mother was directed to make the necessary manipulations at home.

December 4: The shoulder still is tender. When the humerus is abducted and externally rotated to the limit and pressure is made forward on the head of the humerus a distinct grating click or snap can be felt as the head slips over the posterior border of the glenoid. Active flexion of the elbow has developed.

February 5, 1914: Head of humerus still dislocated posteriorly, so on February 7, under ether anæsthesia, bloodless reduction was done, and the arm dressed in the light-house position. The child was taken home the same day, and the mother later reported that almost at once he began to show better use of his hand. Three weeks later it was noted that fair power of extension of the fingers had developed.

March 28: New gypsum case was applied, the humerus remaining in proper position.

May 7: Gypsum dressing permanently removed, the shoulder remaining reduced.

May 28: Since last note mother says he has been using the hand "just like normal." External rotation still limited at sagittal plane.

August 8: Can get hand to mouth, but only in pronation.

January 23, 1915: Uses right hand more than left, and beginning to hold his hand in supination. Active and passive exercises have been continued all the time.

March 20: Good extension in fingers, but none yet in wrist.

January, 1916: As progress seemed slow during the past year, the arm was again dressed in full abduction and external rotation in plaster-of-Paris (applied without any anæsthetic, at the limits of movement), and this dressing was worn for seven weeks. The power of supination and external rotation was decidedly improved when the cast was finally removed.

July, 1916: It was noted that the power of extension of the fingers and wrist was good.

December 30, 1916: Still prefers to use the left hand. Active movements: supination not quite complete, external rotation of

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shoulder only to sagittal plane; abduction and elevation of upper extremity about 30 degrees short of vertical. Passive movements: supination complete, external rotation about 20 degrees beyond sagittal plane; abduction (without elevation of scapula) about 50 degrees (limited by axillary fold muscles). There was a slight hollow beneath the acromion in front, and the head of the humerus was just palpable posteriorly beneath the spine of the scapula (subluxation).

March 10, 1917: The accompanying photograph (Fig. 5) was made, showing the boy putting his hand to his mouth.

CASE III.—*Birth injury of right shoulder, first seen at age of seven weeks. Dislocation of shoulder not observed until age of three years.* Ida May F. came to the Orthopædic Hospital when seven weeks of age, June 8, 1911. This was the first baby in the family, a head presentation, instrumental delivery.

*Examination* showed the right arm hanging by the side in internal rotation. The hand grasp was good; the anteroposterior motions (flexion and extension) of the shoulder were good, and abduction was fair. She could not flex the elbow. Passive motion was normal throughout, and there was no pain on motion. The epiphysis rotated with the shaft. There was some crackling in the region of the shoulder-joint.

Treatment consisted in bandaging the arm in the Velpeau position for two weeks; then massage, passive movements and electricity were given.

October 5, 1911: Can flex elbow, and has more use of shoulder, but it is still in internal rotation.

March 28, 1912: Slight improvement in strength.

June 11, 1914: Careful reëxamination reveals a posterior subluxation of the humerus at shoulder, with a hollow beneath the acromion. The use of hand and elbow are good. There is still limited abduction and external rotation at the shoulder. (It is highly probable that a more attentive examination soon after birth would have detected the posterior luxation of the shoulder; attention was now directed more particularly to this deformity on account of T. T. Thomas's paper.)

March 13, 1917: The child is now six years old. She was treated by massage and passive motions until two years ago. She now gets her hand to her mouth only with the forearm in midpronation and with the arm abducted. She gets her hand to her back easily and fastens her own petticoat. Supination is weak. There is no external rotation at the shoulder beyond the sagittal plane. A slight posterior subluxation of the shoulder persists. She uses her right hand normally, but prefers to use the left. Function could be improved by tenotomy of the subscapularis, and perhaps of the pectoralis major.

CASE IV.—*Subspinous dislocation (luxatio erecta) of left humerus from birth injury; persistent paralysis of hand.* Agnes T., ten weeks old, seen at Orthopædic Hospital, March 7, 1913. This is the fourth child, the previous births being normal. In the present instance "version was attempted" and at birth the left forearm was folded across the front of the baby's neck, in full pronation, and it has constantly rebounded to this position ever since when not held down by a bandage. The mother says that when two weeks old a long splint from axilla to

palm was applied by the family physician, and was kept in place for two weeks; and that when it was removed the child could not move her fingers as well as when first born.

Examination at the age of ten weeks: the arm is held abducted to 90 degrees, and the head of the humerus is palpable beneath the spine of the scapula; there is some grating on attempts at rotation. A bony lump in the axilla is thought to be the glenoid. There is no active power to extend the fingers, wrist or elbow.

Two or three weeks later, the arm having been bandaged to the side constantly, it was noted that the arm stays almost against the side without being held down, and it is assuming the typical posture of "obstetrical palsy."

August, 1913: Now eight months old: the arm comes easily down to the side, and the head of the humerus stays in the glenoid. Wrist drop and paralysis of the triceps persist. Fair power in biceps, and fair grip in fingers; no power in axillary fold muscles; deltoid is doubtful.

October, 1913: Head of humerus is clearly anterior to acromion and there is no palpable deformity as compared with the uninjured side. Grip is good, the hand as a rule staying clenched and the wrist flexed, but not so persistently as before. No power yet in musculospiral; some power in pectoralis major. Dr. H. P. Boyer reported that the electrical examination of the muscles was a little doubtful, but he thought there was no reaction of degeneration in the pectorals or the extensors of the fingers. There was "some response to the Faradic current."

June, 1914: Very little further improvement has occurred. Massage and electricity have been given twice weekly. She can now abduct her shoulder (deltoid) to 90 degrees; the axillary fold muscles are good, and the biceps is good. There is no power in the triceps or in the extensors of the fingers; there is very slight power in the flexors of the fingers. The fingers are still held clenched and the wrist flexed. Passive movements: external rotation at the shoulder is easy to beyond the sagittal plane; the elbow can be extended to 170 degrees, supination is normal, but pronation a little limited. The mother says the child has been *biting* her hand (not very hard) for four or five months. A posterior splint was applied to keep the fingers and wrist in extension, and all other treatment was suspended.

August, 1914: Does not bite hand any more; hand no longer stays flexed, but there is no power in the fingers nor in the extensors of the wrist. The posterior splint was continued.

November, 1914: Has learned to hold a glass of milk or water in the bent elbow and drinks easily from it.

January, 1915: Burned the left elbow a few days ago, and it seemed to give her no pain. The finger nails of the paralyzed hand require to be cut about three times as often as those of the normal hand, the latter being worn down by use.

March, 1917: Now four years of age. The hand is useless—in flexion and ulnar deviation; she can barely flex the fingers. The biceps

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and triceps have very fair power. She gets the back of her wrist to her mouth, and holds articles in the bend of her elbow with great security.

*CASE V.—Subspinous dislocation of humerus, with complete flaccid paralysis of arm; reduction by arthrotomy.* Catharine B. came to the Episcopal Hospital in September, 1913, when past three years of age (Fig. 6). There were two older children: the first (now seven years old) had the left shoulder "broken in birth"; the second child (now six years old) had "the nerve hurt" in birth (right shoulder), but "both came all right about six weeks after birth." (See Cases Va and Vb). A fourth child, born subsequent to this visit (in May, 1914) was killed during delivery.

Catharine was born head first, and no instruments were used. She seemed to have no sensation in the left arm. It has always been utterly useless. She chews the fingers, and has burned the hand several times without evincing any sensations of pain.

*Examination.*—There is complete flaccid paralysis of the left upper extremity; probably, it was thought, the lesion was a tearing out of the roots of the brachial plexus from the spinal cord. She has been seen by nerve specialists and orthopædic surgeons, who told the mother nothing could be done. Owing to the complete absence of sensation, persisting for over three years, this seemed reasonable advice, and it was repeated.

June 15, 1914: Nine months after the first examination the child was sent for, for reëxamination, especially as it had not been noted at the first examination whether or not there was a posterior dislocation of the shoulder. To-day it is learned that the child has not burned her fingers since Christmas, and that soon after the first of the year she began to move her fingers. She can now flex the shoulder slightly. The axillary muscles have fair power; there is some power in the biceps, and she can extend the wrist well. There is a subspinous dislocation of the humerus. Operation was now recommended to secure reduction of the dislocation, since it had been determined by an experience with six cases of reduction of similar dislocations (three "bloody" and three "bloodless" reductions), all treated since this patient was first seen, that a considerable degree of improvement might be expected in apparently paralyzed muscles if deformities were overcome and the weak muscles were allowed to work at a better advantage.

*Operation* (December 28, 1914).—Patient now four years of age. Senn's incision, with temporary resection of the acromion. The acromion was cut at its origin from the spine by an osteotome, but in turning it forward the acromion fractured through its epiphysial cartilage. The intervening detached piece of acromion was laid aside in dry sterile gauze and was re-implanted at the conclusion of the operation. The tendon of the subscapularis was divided, thus allowing external rotation of the humerus until the flexed forearm was in the coronal plane. The head of the humerus was thus easily and fully reduced to its normal position. The tendons of the supra- and infraspinatus muscles were then shortened; the detached piece of the acromion was replaced and fastened to the spine of the scapula by a small Lambotte screw; the cartilaginous tip of the acromion was turned up again and sutured to

the periosteum covering the head of the screw; and the fascia and skin were closed with interrupted chromic gut sutures. The arm was dressed in abduction and external rotation, in plaster-of-Paris.

January 9, 1915: Went home.

February 15, 1915: New case applied. One granulation in the line of incision.

March 29: Case removed. Massage ordered. Incision healed.

April 10: Can get hand to mouth, but only with arm in abduction. Has fair power of flexion and extension in elbow, but scarcely any motion in hand.

November 15, 1915: Dislocation stays reduced; the acromion is solid. She can put her hand to her mouth with forearm in pronation and the humerus abducted. She has no active external rotation; has slight power in the triceps, can flex elbow to 45 degrees, and there is passive extension of the elbow to 150 degrees. She has some power in the extensors of the wrist, very slight power in the thumb, fair pronation and supination. There is no power in the other muscles of the hand.

*CASE Va.—Subspinous dislocation of left shoulder; slight disability.* Anna B., aged seven years, is the eldest sister of Catharine B. (Case V). It was a head presentation at birth, and no instruments were used; but after the head was delivered, the shoulders stuck, and the labor was difficult.

*Examination.*—The mother brought this child to the Episcopal Hospital, June 15, 1914, by request. Except for the fact that the baby's "shoulder had been broken in birth" it was thought that she had recovered perfectly by the age of six weeks. Examination showed, however, that there was a subspinous dislocation of the humerus, with the characteristic internal rotation of the arm, which was carried into marked abduction on putting the hand to the mouth. Treatment was declined by the parent, and was not urged, as the disability was slight (Fig. 6).

*CASE Vb.—Birth injury of right shoulder, without dislocation of the humerus.* Mary B., aged six years, was the sister of the patients already described (Cases V and Va). She was brought to the Episcopal Hospital for examination, by request, June 15, 1914. There was the characteristic attitude of carrying the injured limb, with the arm in internal rotation and the forearm pronated. No dislocation of the shoulder was present, but there was limitation of external rotation and of supination, and in carrying the hand to the mouth the arm was forced into marked abduction. The disability was so trifling that no treatment was recommended (Fig. 6).

*CASE VI.—Subspinous dislocation of humerus, reduction by arthrotomy.* Theresa M. came to the Episcopal Hospital when five years old, April 5, 1915. She was the youngest of seven children, all but one of the six others having died at birth. In the instrumental delivery of Theresa, the right arm was injured.

*Examination.*—The arm is held in internal rotation with the elbow flexed; the head of the humerus is absent from its normal site in front of the acromion, and is palpable posteriorly beneath the spine of the scapula. She cannot put her hand to her mouth in supination, and in the act the arm is abducted until the elbow is higher than her ear (Fig. 7).

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*Operation* (April 14, 1915).—Senn incision. Acromion detached and turned down. After section of subscapularis tendon the head of the humerus was replaced in the glenoid; the tendons of the supraspinatus and infraspinatus were plaited to shorten them and maintain the external rotation; and the acromion was replaced and held in position by sutures of chromic gut. The arm was dressed in plaster-of-Paris in full abduction and external rotation.

April 22, 1915: Went home.

May 28, 1915: New plaster case applied.

July 12, 1915: Plaster case removed permanently. Reduction is maintained, but shoulder is stiff and painful.

August 2, 1915: Can get hand to mouth in supination, but motion in shoulder is only about half normal. Continue massage and passive motion.

December 6, 1915: Nearly perfect result (Fig. 7). Can put hand to mouth in supination, and behind head; cannot put it behind back. Extension of elbow to 150 degrees. Has good supination in forearm, has almost normal external rotation, and can abduct arm to 90 degrees.

CASE VII.—*Subspinous dislocation of shoulder; bloodless reduction.* Edward J., four years old, is a brother of Case IX. Three sisters are normal, but the third boy, born February 7, 1916, by instrumental delivery, was killed during birth (his weight is said to have been 16 pounds). When the present patient was examined, in September, 1914, there was a subspinous dislocation of the left humerus, slight cubitus varus, and limited rotation in the forearm. The arm was not so useless as that of the patient's brother (Case IX), but like Tom, he could not get his arm into external rotation, nor his forearm into supination (Fig. 8).

*Operation* (September 8, 1914).—Bloodless reduction, under ether anæsthesia; with the child lying on his abdomen, and the arm in abduction and the forearm hanging over the edge of the table, pressure was made downward on the head of the humerus, at first with the arm in internal rotation; then gradually, *after* reduction had been secured (ascertained by palpating the head of the humerus in front of the acromion, and observing that the flexors of the forearm had become tense, as do the hamstrings when a congenital luxation of the hip is reduced), the humerus was worked into external rotation. When complete reduction was effected, an upward dislocation of the acromial and of the clavicle was produced. The limb was dressed in plaster-of-Paris, with the humerus horizontal in the coronal plane, and the forearm vertical (full abduction and external rotation of the shoulder). The reduction was attended by a distinct jump and click, was easily reproduced, and again reduced, with characteristic jump and click.

November 6, 1914: Case removed eight weeks after reduction, which was still present.

November 9: Dislocation has recurred.

November 11: Bloodless reduction under ether anæsthesia, as before; dressed in plaster-of-Paris in same position.

December 28: New case applied. Shoulder stays reduced.

February 12, 1915: Case removed, three months after second reduction. Humerus remains in place.

April 10: Good use of hand, but humerus does not stay very far forward. Can get hand to mouth without much abduction of arm, but not in supination (Fig. 9).

March 13, 1917: Two years and four months after reduction. Has had no treatment for two years. He is nearly seven years old. He can get his hand to his mouth only in pronation, barely to his head, and not at all to the small of his back. Passive external rotation of the shoulder is possible until the flexed forearm lies almost in the coronal plane; active external rotation is limited at 45 degrees (mid-way between sagittal and coronal plane). Passive supination of the forearm is limited just beyond the mid-position; active supination stops just short of the mid-position. His arm and hand are very useful and still improving.

CASE VIII.—*Subspinous dislocation of humerus; reduction by arthrotomy.* Joseph B., five years old, came to the Episcopal Hospital February 2, 1914. He was the fourth child of his parents, three older and one younger children being normal. The fifth child was delivered instrumentally, and died in two hours. Patient was also a case of instrumental delivery, and his left arm has been paralyzed ever since birth.

*Examination.*—He holds the left upper extremity in internal rotation and slightly abducted at the shoulder, flexed at the elbow, and hyperextended at the wrist (Fig. 10). When trying to put hand to mouth he raises arm in abduction and internal rotation, and the flexor surface of the forearm is carried against the mouth (Fig. 10, C). He cannot get his hand to his mouth, and the hand is useless. The head of the humerus is absent from its normal location in front of the acromion and is visible and palpable behind the spine of the scapula. His grip is good, but he cannot flex his wrist. The biceps is good, and there is slight power in the triceps. There is very slight power in the extensor carpi radialis. He cannot flex the index finger as well as the others, nor the thumb; and he cannot extend his fingers. Elbow cannot be extended beyond 160 degrees, and there is cubitus varus (195 degrees, i.e., the forearm falls 15 degrees to the inner side of the axis of the humerus). The axillary fold muscles and the trapezius are good.

*Operation* (February 7, 1914).—Senn's incision; temporary resection of acromion. Lesser tuberosity could be only very imperfectly exposed until after division of subscapularis tendon, which allowed external rotation of humerus, thus bringing lesser tuberosity into view. The head of the humerus could now be pushed forward in front of posterior lip of glenoid, and dislocation satisfactorily reduced. The supraspinatus and infraspinatus tendons were then shortened by plaiting to maintain external rotation; the acromion was replaced and fixed in position by chromic sutures, and the skin wound closed. Dressed in external rotation and abduction (Fig. 10, D).

February 28: Went home.

May 20: Case removed.

June 1: Massage and passive motions ordered.

August 31, 1914: Shoulder remains in joint. Better motion of the arm. Splint to hold wrist slightly flexed.

January 17, 1916: Has full external rotation, and almost normal



supination. He can just put his hand to his mouth in supination (Fig. 11). He cannot put it behind his head or behind his back.

March 13, 1917: Now 8 years old, over three years since operation. Puts hand to mouth normally, but wrist remains in hyperextension. There is a strong grip in the fingers. Active flexion of the elbow is normal, but extension is impossible beyond 135 degrees (passive extension to 150 degrees). There is no active rotation in the shoulder, nor any active supination or pronation in the forearm. There is good power in the deltoid. He uses his hand constantly for holding things.

CASE IX.—*Subspinous dislocation of humerus; reduction by arthrotomy.* Tom J., aged six years, with his brother Edward, aged three years (Case VII), similarly deformed, was brought by his mother to the Episcopal Hospital January 22, 1913. After this date the patients were not seen until September, 1914. Boy's left shoulder had been injured in birth, and he has never had any use of the arm. Three sisters are normal, but the third boy, born February 7, 1916, by instrumental delivery, was stillborn (weight said to have been 16 pounds).

*Examination* (September, 1914).—The left arm hangs in internal rotation, with the forearm in pronation, and is several inches shorter than the right arm (Fig. 8). Finger movements are normal, but there is no active power of extending the wrist, and passive extension is possible only to 165 degrees. The elbow can be extended to 160 degrees, and flexed normally; there is cubitus varus. The head of the humerus is palpable behind the spine of the scapula, and the tip of the acromion is turned down. Active abduction at the shoulder (including rotation of the scapula) is possible to 75 degrees, and passively to 150 degrees.

*Operation* (September 8, 1914).—Senn's incision, with temporary resection of the acromion. The shoulder-joint was opened above the greater tuberosity, which was the only portion accessible. The head of the humerus lay against the posterior lip of the glenoid process, in posterior subluxation; and where the edge of the glenoid impinged on the humerus a deep longitudinal groove had been worn in the cartilaginous head of the humerus. It now became possible to reduce the luxation by forward pressure, if the humerus was in internal rotation, but impossible if in normal position of rotation, and also impossible to rotate the humerus out after reduction was secured. Therefore the subscapularis tendon was cut from within the joint. At once reduction became easy when the humerus was in external rotation. While the humerus was maintained in reduction, with the arm abducted and externally rotated, the tendon of the supraspinatus was plaited, to aid in maintaining abduction and external rotation; the acromion was replaced and held in position by sutures of chromic gut uniting the deltoid, periosteum and trapezius over it. The skin was similarly closed with chromic gut. The arm was dressed in plaster of Paris in the usual position of abduction and external rotation.

September 14: Went home.

November 6, 1914: Plaster case removed.

December 7, 1914: Humerus stays reduced. Arm no longer in internal rotation. Fair power regained in musculospiral nerve. Passive movements normal, except extension of shoulder, which is absent. He can get his hand to his mouth in full supination (Fig. 9, A).

April 16, 1915: Humerus remains reduced. Gets hand to mouth very well. Very little disability.

February 21, 1916: Humerus remains reduced. External rotation normal. Deltoid feeble. Cannot raise hand above nor behind head. Can put hand to mouth, but not in *full* supination. Passive abduction in shoulder 60 degrees. Some weakness still in extensors of wrist and fingers. Triceps and biceps good. Supination: active, one-half normal; passive, normal. Does not use the arm very much.

March 13, 1917: Mother reports that child died from appendicitis in January, 1917. She says the arm was "just grand."

CASE X.—*Subspinous dislocation of humerus, deformity of elbow, and wrist drop; arthrotomy of shoulder; excision of head of radius, arthrodesis of wrist by bone transplant.* George W. was fifteen years of age when he came to the Episcopal Hospital May 24, 1914. He had three brothers and two sisters living and well. His right shoulder had been injured in birth, and his arm was practically useless.

*Examination.*—His right arm hangs in internal rotation, the humerus abducted, the elbow flexed, the forearm in pronation. The head of the humerus is absent from its normal site in front of and below the acromion and is visible and palpable below the spine of the scapula. Passive movements: these are normal in the fingers and hand, and in the wrist, except adduction at the wrist which is lost. Extension of the elbow to 145 degrees, and flexion to 50 degrees. Complete pronation and supination are both lacking, rotation being present only through an arc of 30 degrees, most limited in supination. The head of the radius is prominent beneath instead of anterior to the external condyle, being luxated posteriorly. At the shoulder abduction of the humerus is possible through an arc of 60 degrees, flexion through 45 degrees, and extension through 20 degrees. External rotation at the shoulder is possible until the flexed forearm just passes the sagittal plane. Internal rotation when the humerus is abducted is similarly limited just before the forearm reaches the coronal plane. The motions of the scapula are not limited. The head of the humerus is dislocated posteriorly beneath the spine of the scapula. The acromion is prominent, with its upper flat surface looking outward, being twisted through an arc of 45 degrees. The clavicle is subluxated upward. The coracoid is normal. Active movements: he has scarcely any grip in his hand; there is slight power in the lumbricals and interossei, fair power of flexion of the thumb, very little adduction of thumb. The wrist cannot be actively extended (Fig. 13, B), but if hyperextended passively it can be held weakly in extension momentarily (Fig. 12). There is no power of rotation in the forearm. The elbow can be actively extended to 145 degrees, and flexed only to 70 degrees (passive flexion possible to 50 degrees). At the shoulder there is active but weak abduction of about 30 degrees, flexion of 30 degrees (secured solely by rotation of the scapula), and no extension, no external rotation, but good internal rotation. The axillary fold muscles are good, and there is fair power in the deltoid. The triceps is good. He cannot get his hand to his mouth, it being impossible for him to raise his arm higher than the plane of his shoulders.

*Operation* (May 31, 1914).—Senn's incision, temporary resection

of the acromion. The bicipital groove was found directly in line with the external condyle of the humerus, apparently owing to the gradual internal rotation of the shaft of the humerus below the tuberosities. Section of the tendon of the subscapularis at once allowed external rotation of the arm until the forearm was in the coronal plane. It was still impossible to secure complete reduction of the dislocated head of the humerus, owing to tenseness of the pectoralis major. The tendon of this muscle was then divided through another incision (in the line of the anterior axillary fold), and at once easy reduction of the head was secured by external rotation, abduction, and slight pressure forward on the head. If abduction was carried too far the humerus again luxated posteriorly and upward (tension on teres major?). The most stable position was in abduction of 70 degrees and external rotation about 20 degrees short of the coronal plane. The outer end of the clavicle, which was luxated upward, was excised, and this allowed the acromion to come back into better position; but the tip of the acromion was so far bent downward that it kept the head of the humerus pushed backward. Therefore a wedge-shaped piece (base upward) was cut off the portion of the acromion temporarily displaced (not from the spine of the scapula), so that when the remaining portion of the acromion was replaced against the spine of the scapula, the tip of the acromion no longer interfered with the proper position of the humerus, but rode above it. The acromion was fixed against the scapula with a screw. The muscles and skin were sutured separately with interrupted sutures of chromic gut, and the arm was dressed in plaster of Paris in abduction of about 70 degrees and external rotation almost to the coronal plane (Fig. 12).

First dressing six weeks later, when another cast was applied and worn until three months after operation. It was next decided to operate on the elbow, as pronation and limitation of extension persisted and were evidently due to the dislocation of the head of the radius.

*Second Operation* (October 14, 1914).—Kocher's external incision. The brachioradialis and extensor carpi radialis were detached from the supracondylar ridge and pushed forward, and the anterior surface of the capitellum was exposed. The external lateral ligament was then cleared and the head of the radius was exposed in front of it. The head luxated posteriorly in extension of the elbow and limited further extension. The neck of the radius was divided by a Gigli wire saw, and the head removed. This allowed 20 degrees more of extension. The anterior capsule of the elbow-joint was next divided, and then the anterior tendinous surface of the brachialis anticus, its muscle fibres readily yielding to extension when once the aponeurosis was divided. Complete extension was not even yet possible, so the olecranon was exposed behind the external lateral ligament, by displacing the triceps backward, and its tip was cut off (1.25 cm.) by osteotome. Extension to 170 degrees was now possible. The wound was closed in layers, and the arm dressed on an internal angular splint.

November 30, 1914: Passive motion in elbow 65 to 145 degrees. The wrist is no stronger than at first examination, but he now has a fair grip in his hand. He cannot flex his elbow actively beyond 90 degrees, and cannot get his hand to his mouth.

December 7, 1914: Brace applied to overcome wrist drop.

January 25, 1915: Elbow, passive movements, 65 to 155 degrees; active, 85 to 155 degrees. Shoulder movements are more free than before operation, and chief disability now is from wrist drop.

*Third Operation* (March 3, 1915).—Curved incision over extensor surface of wrist, slightly convex to ulnar side, from base of index metacarpal to 3 inches above wrist-joint. Annular ligament incised between thumb and index extensors, opening wrist-joint. Radius bared of periosteum. With twin circular saw a slot (6 to 7 mm. in width) was cut in extensor surface of radius, across carpus (scaphoid, trapezoid, and os magnum) and in adjoining surfaces of index and middle metacarpal bones. The slot was cleared of bone with chisel and gouge forceps; all fragments were preserved. A transplant of corresponding width and length was then cut from the subcutaneous surface of left tibia, and inserted in the groove at the wrist. Six transverse saw cuts were made in the transplant so as to allow it to be bent to permit slight hyperextension of the wrist. It was fixed in place by suturing periosteum and fascia over it, with No. 3 chromic gut. The fragments removed from the wrist were then inserted in the defect in the tibia, and both wounds closed. The wrist was dressed on a palmar splint of gypsum in slight hyperextension.

March 15, 1915: Returns to Dispensary for dressing.

March 22, 1915: Good union in wrist. Incision healed.

April 12, 1915: Skiagraphs show transplant in good position, and leg filling in with fragments transplanted from wrist. Gypsum splint continued.

May 24: Binder's board splint applied. Wrist has lost its hyperextension, but remains at 180 degrees.

June 28: Carries objects in hand, dresses himself, and can hold his French horn better. (He plays in an orchestra.)

July 26: Can now close all fingers but fifth. Improvement is marked.

October 5: A few days ago he broke his transplant in the wrist, while asleep, in turning in bed. This allows motion in the wrist of 30 degrees (180 to 150 degrees). Hand continues to grow more useful.

October 14, 1915: Skiagraph shows transplant incorporated with radius and ankylosed to the index metacarpal.

March 12, 1917: Nearly three years after first coming under observation: He finds his hand perfectly useful in playing the French horn. (It should be mentioned that the French horn is played by the left hand, and that the right hand is placed in the flaring end of the horn to support its weight, etc.) He has practically normal use of the thumb, index and little fingers. The fourth and fifth fingers have very little power. There is passive motion at the wrist from 170 to 140 degrees, flexion being possible actively, but there being no active power of extension (Fig. 13). Pronation in the forearm is complete, both passively and actively; supination, actively and passively, is possible to the midposition; that is to say rotation has increased from a range of 30 degrees when first seen to a range of 50 degrees or more at present. There is passive motion at the elbow from 60 to 160 degrees, and active motion from 90 to 160 degrees. At the shoulder passive abduction is 60 de-

grees, and active 45 degrees; passive flexion is 90 degrees and active flexion 60 degrees. He is still unable to get his hand to his mouth or to the small of the back.

Compared with his condition when first seen, his present condition is markedly improved; both his parents and himself are satisfied.

CASE XI.—*Disability from contractures; open tenotomies.* Joseph V. was brought to the Episcopal Hospital when twelve years old, April 19, 1915, for disability persisting from an injury to the right shoulder region during birth. He had four sisters, none of them injured in birth, and one brother, who had died of unknown cause (no birth injury).

*Examination.*—He carries his arm in internal rotation, and he cannot put his hand to his mouth nor behind his head. He cannot flex his elbow beyond 90 degrees nor can he fully extend it. Rotation in the forearm (active and passive) is limited in both supination and pronation. Passive movements in the elbow and wrist are not limited. There is passive external rotation at the shoulder only to the sagittal plane; there is no passive extension of the shoulder; passive abduction is possible almost to 90 degrees, but only with the arm anterior to the coronal plane (in partial flexion). Active movements of the hand and fingers are normal. There is good active flexion of the shoulder (by contraction of the coracobrachialis and pectoralis major), but no active extension nor abduction. There is no posterior dislocation of the humerus. The end of the clavicle is slightly above the level of the acromion.

It was recommended that the limitations to external rotation and abduction at the shoulder be overcome by a series of plaster casts. This was declined by his parents, and the boy was not seen again for almost a year (March 13, 1916). No improvement had occurred, and operation was recommended and accepted (Fig. 14, A). Re-examination shows slight posterior subluxation of the humerus.

*Operation* (March 20, 1916).—Ether. Incision as for excision. Division of tendon of pectoralis major allowed normal abduction. The latissimus dorsi was not tight in abduction. Division of the tendon of the subscapularis, while it was kept under tension by attempts to secure external rotation, allowed suddenly full external rotation. This incision passed through the joint capsule, making the head of the humerus visible, and causing it to tend to luxate anteriorly; but even in full external rotation and abduction it did not actually luxate. The bicipital groove seemed displaced externally, looking outward rather than forward. Wound closed without drainage and arm dressed in full abduction and external rotation in plaster of Paris.

March 25: Went home.

May 5: New case applied.

June 9: Case removed. Ordered massage and passive motion.

June 25: Can put cap off and on.

March 7, 1917: One year after operation. Gets hand to mouth easily in supination, but arm still abducts slightly in this movement (Fig. 14, B). Uses right hand now in writing (formerly used left). Active external rotation is possible to 60 degrees beyond the sagittal plane (Fig. 14, C). passive external rotation perhaps 10 degrees further.

Active abduction is possible through an arc of 60 degrees, passive abduction perhaps 10 degrees further.

CASE XII.—*Disability from contractures; open tenotomies.* William L. came to the Episcopal Hospital November 23, 1914, at the age of eleven years. His right arm had been injured in birth, and great disability persisted.

*Examination.*—Carries arm in internal rotation and cannot get hand to mouth; even with the aid of the left hand he can get his right hand to his mouth only with wide abduction of the humerus, and with the hand in full pronation. His hand is practically useless. There is atrophy of the supra- and infraspinatus muscles, of the biceps and triceps; and marked contractures of the pectoralis major, the subscapularis, and to a less disabling degree, of the latissimus dorsi. Passive external rotation is impossible beyond the sagittal plane. Extension of the elbow is limited.

*Operation* (December 9, 1914).—Ether. Incision as for excision of shoulder. Subscapularis was divided at its insertion into the lesser tuberosity; this at once allowed external rotation to the coronal plane. Then the tendon of the pectoralis major was lengthened by the usual method of tendon lengthening, known as Z-plasty, the lower half of the insertion being divided close to the humerus, and the upper half of the tendon being cut about 3 cm. nearer the chest. Thus fully one inch lengthening was secured. Dressed in the usual position (abduction and external rotation) in plaster of Paris.

December 15: Went home.

January 22, 1915: Six weeks and a half after operation: case removed.

February 1: Cannot get hand to mouth in supination. Ordered massage and passive motions.

February 8: Learning to write with his right hand (previously used left hand). Can easily put hand to mouth in supination, and to the top of his head. The improvement was most striking.

March 22: Can put hat off and on, and put hand to back of neck.

May 24: Very good use of hand. Still tends to abduct humerus in flexing elbow. Passive external rotation of the humerus is as good as on the left.

December 6, 1915: Uses hand for everything. Good grasp. Full extension of the elbow. Active external rotation to the sagittal plane.

January 17, 1916: Almost complete active supination.

February 12, 1917: There is power in the deltoid. Can hold his hand above his head. There has been continued improvement during the year.

CASE XIII.—*Flaccid paralysis of shoulder (right) with flail joint; transplantation of pectoralis major to supplant deltoid; of pronator radii teres to become supinator, and of flexors of carpus to become extensors.*—Carl C. was thirteen years of age when he was brought to the Episcopal Hospital, October 20, 1913. He is the first child of his parents; the second and fifth children died at birth, but the third and fourth children are normal. This patient was born by instrumental delivery (head presentation), and his right shoulder was injured during the process. He was treated by massage and electricity



FIG. 1.—Curved incision around acromion, flap of skin turned up.

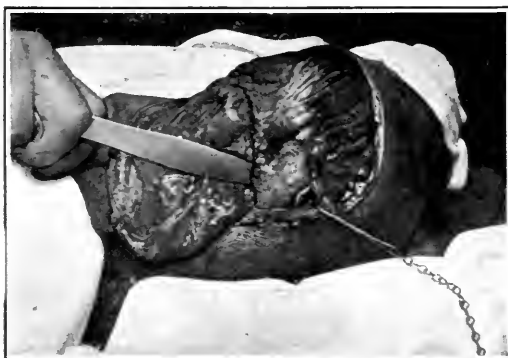


FIG. 2.—Spine of scapula exposed and retractor passed under base of acromion.



FIG. 3.—Acromion divided at its base and turned forward. The long tendon of the biceps is clearly exposed; in front of it the subscapularis just comes to view; posteriorly the supraspinatus and infraspinatus muscles are seen.



FIG. 4.—Case II. Subspinous dislocation of right humerus; patient aged three months. Note that on the injured side (arm held close to body in internal rotation) the epiphysis of the head of the humerus is far removed from the glenoid.

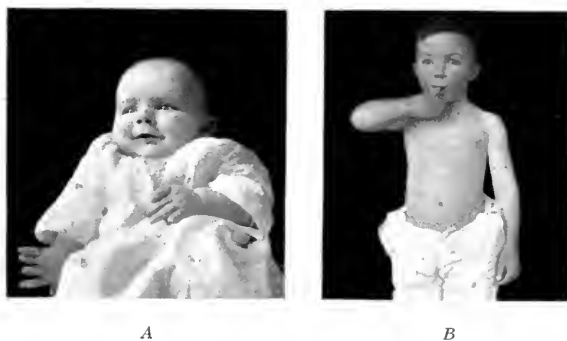


FIG. 5.—Case II. A, aged six months; B, aged three and one-half years.



FIG. 6.—Three sisters with birth injuries of shoulders. (Fourth child killed in delivery.) A, child aged three years, dislocation of left shoulder; B, child aged six years, right shoulder (no dislocation); C, child aged seven years, dislocation of left shoulder.





*A*



*B*

FIG. 7.—Case VI. *A*, child aged five years, posterior dislocation of right shoulder from injury at birth  
*B*, eight months after operation.



*A*

*B*



*A*

*B*

FIG. 8.—Cases VII and IX. Birth injuries of left shoulders. *A*, child aged four years; *B*, child aged seven years.



*A*

*B*

FIG. 9.—Cases VII and IX. Seven months after operation. *A*, "bloody"; *B*, "bloodless."



*A*



*B*



*C*



*D*

FIG. 10.—Case VIII. Child aged five years. Subspinous dislocation of left humerus. *A*, rear view; *B*, front view; *C*, attempt to put hand to mouth; *D*, after operation, dressed in the usual position.



FIG. 11.—Case VIII. Child aged seven and one-half years. Birth injury of left shoulder. Two years after open operation.

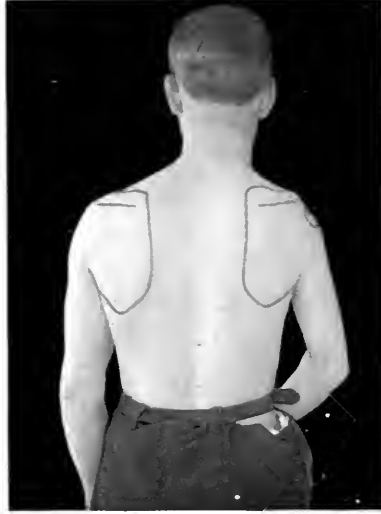


FIG. 12.—Case X. Patient aged fifteen years. Subspinous dislocation of right humerus. After reduction the arm was dressed in the most stable position.

A



B



C

FIG. 13.—Case X. A, photograph made September 21, 1914, four months after operation on shoulder; external rotation restored (compare with Fig. 12). B (February 15, 1915) and C (March 3, 1916), hand and wrist before and after arthrodesis.

*A**B**C*

FIG. 14.—Case XI. Showing marked improvement in function secured by tenotomies. *A*, March 20, 1916; *B*, one year after operation; *C*, March 14, 1917, one year after operation.



A



B

FIG. 15.—Case XIII. Brachial birth palsy of right upper extremity, with flail shoulder, and loss of supination in forearm and of extension in wrist. A, disability before operation; B, result four months after operations.



FIG. 16.—Case XIII. Showing the incision employed for transplantation of pectoralis major to take the place of the paralyzed deltoid. Before this operation the humerus became subluxated anteriorly when the position shown in the photograph was assumed, and the arm could not be drawn forward without the aid of the left hand. Voluntary flexion of the shoulder-joint is now easy.

from the age of seven weeks to that of one year. Since that time nothing had been done, and his parents were now anxious to know if something could not be done to lessen his disability.

*Examination.*—He carries the right arm rotated in, the elbow flexed, and the forearm pronated. The limb is useless. Passive movements were possible as follows: Shoulder can be abducted to 60 degrees; can be rotated externally about half the normal extent; while flexion and extension in the shoulder are normal. Flexion in the elbow is normal, but extension is very slightly limited. Wrist motions are normal. Supination beyond the mid-position is impossible. Active motions are as follows: scarcely any motion in shoulder, but the axillary fold muscles are good. The biceps and triceps have fair power. There is no active supination; no power in the extensors of the carpus; extensors of the fingers are good, flexors of the carpus and the fingers are good. He can put the back of his hand to his mouth, but not the fingers, owing to the persistent pronation (Fig. 15, *A*). Whenever the arm gets back of the plane of the body the humerus luxates forward at the shoulder-joint and it remains luxated anteriorly until with his left hand he pulls the paralyzed arm forward into a position of flexion and adduction. This causes great disability, and is evidently due to the complete paralysis of the deltoid. Limitation of external rotation at the shoulder and persistent internal rotation indicate there is no paralysis of the internal rotators.

The treatment proposed was to secure supination of the forearm and to prevent the recurrent anterior luxation of the shoulder.

*Operation on Forearm* (August 27, 1913).—Esmarch band above elbow. The pronator radii teres was transplanted through the interosseous space around the posterior and external surfaces of the radius, and while the forearm was maintained in full supination (which became possible after section of the teres muscle) it was sutured to the lateral and flexor surfaces of the radius, the sutures being passed through drill holes in the radius. Next the flexor carpi radialis was transplanted (superficial to the thumb extensors) into the extensor surface of the base of the index metacarpal. Finally the flexor carpi ulnaris was transplanted to the extensor surface of the carpus (unciform or cuneiform bone). The arm was dressed on an anterior angular splint, with the forearm in full supination and the wrist hyperextended.

September 17: First dressing: all incisions healed. Can carry hand to mouth in supinated position. Wrist stays hyperextended.

*Operation on Shoulder* (September 24).—Incision from third costal cartilage to sternoclavicular joint, along clavicle to acromion, thence down outer surface of shoulder nearly to insertion of deltoid (Fig. 16). This large flap was turned down and the clavicular and upper sternal fibres of the pectoralis major were cut at their origin, and, with care to preserve their nerves and vessels, these portions of the muscle were shifted out over the paralyzed deltoid and were sutured to a groove cut by Hey's saw in the acromion and outer third of the clavicle. The incision was closed without drainage. A continuous linen suture was employed for the skin. The limb was put up in plaster of Paris, in abduction and external rotation, with the forearm still in full supination.

October 4: Went home.

October 20: Sutures removed through opening in case. Incision healed.

November 3: Case removed, six weeks after operation. Arm carried in sling. Massage ordered.

November 10: Sling removed. Passive movements ordered.

November 24: Can put hand to mouth in supination well. When arm is put behind back he can pull it forward easily by action of transplanted pectoralis major. He can actively extend the wrist, but there is still a tendency to ulnar deviation of the hand.

December 8, 1913: To go to school. Can take hat off and on with his right hand.

December 15: Slight active supination. Photograph in Fig. 15 shows his present condition.

December 27: Can cut his meat with his right hand.

January 17, 1916 (two years later): Works as messenger boy. Can button coat with right hand; can with difficulty get hand to back of head and to mouth (but not in supination). Wrist is in ulnar deviation. He can actively flex and extend wrist and fingers. Active supination is weak. The biceps is good (formerly very feeble). The head of the humerus is in position. There is no active abduction, but he can carry arm forward in sagittal plane (flexion of shoulder) by contraction of the transplanted pectoralis major, which can be felt contracting well.

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## PULSE RATE AND BLOOD-PRESSURE OBSERVATIONS AS AN AID IN THE TREATMENT OF HEAD TRAUMAS

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It is a recognized clinical fact that a rapid encroachment upon the intracranial space by any foreign body is frequently associated with a slow, high tension pulse. This phenomenon has been an almost uniform accompaniment of artificially produced cerebral compression in the laboratory experience of many investigators.

As the brain tissue is practically incompressible and is enclosed in a non-expansible skull box, the introduction of an intracranial foreign body is only possible through the emptying of the surrounding vascular channels.

In 1902, Cushing<sup>1</sup> produced, experimentally in dogs, a general cerebral compression, by allowing normal salt solution, warmed to body temperature, to enter the cranial space through a cannula screwed into a trephine opening in the arch of the atlas. The tension of the fluid was regulated by the degree of elevation of a pressure flask and was recorded on a revolving drum simultaneously, and in exactly the same way as the arterial pressure. Direct observation of the cortical circulation was made through a circular disc of glass with a bevelled edge, made to fit a large trephine opening near the mid line, so as to expose the longitudinal sinus, as well as the surrounding pial vessels. The rate and excursion of the respiratory wave was also recorded on a revolving drum with the intracranial and arterial pressures. In this way observations were made on the effect that various degrees of intracranial pressure had upon the respirations and general circulations, as well as the vascular alterations of the brain itself. When the pressure of the fluid in the intracranial space was allowed to increase, there was first noted a distinct evidence of venous stasis, with bluing of the exposed convolution and later a narrowing of the longitudinal sinus. As the intracranial tension approximated the arterial pressure a condition of anæmia was produced as shown by the blanching of the cortex, the veins remained filled with blood and very little if any circulation was evidenced. As the pressure produced is a general one, a similar anæmia is present in the medulla, where the vital centres are poorly nourished, if at all. This anæmia of the medulla stimulates the vagus centre, slowing the pulse, and likewise the vasomotor centre, resulting in an increase in the general arterial pressure to a point above that of the high tension in the intracranial space. The pale cortex becomes pink and the respirations, which are very irregular, or perhaps have ceased entirely, are again resumed as a result of the return of blood to the respiratory centre. If, after this readjustment of circulation

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<sup>1</sup> American Journal Medical Sciences, 1902, vol. 124, p. 375-400.

has taken place, the intracranial pressure is again increased to a point above that of the arterial pressure, anæmia is again produced and the blood-pressure once more rises in its turn, to the point of exceeding the intracranial tension. Thus the process may be continued until the arterial pressure is raised to a point two or three times its normal level, in an attempt to exceed the intracranial pressure and supply normal nutrition to the bulbar centres. With the continued increase of the intracranial tension, sooner or later a time comes when the vasomotor centre weakens and is no longer able to supply sufficient blood to the medulla. The blood-pressure falls below that of the intracranial tension and the animal dies with a low blood-pressure and rapid pulse, which may continue for some time after the respiration has ceased, a typical respiratory death.

In order to determine whether this physiological response represented a regulatory mechanism which controls the rise in blood-pressure, or is nothing more than some uncontrolled reaction from irritation of the vasomotor centre, he first eliminated the inhibitory action of the *vagus* centre by dividing both vagi. Under these conditions, the blood-pressure and degree of intracranial tension followed one another with the same regularity as before, the blood-pressure always tending to remain slightly above that of the tension in the intracranial space. If at the same time a loop of bowel was exposed, the calibre of the mesenteric vessels was seen to diminish during the great rise in blood-pressure and to dilate if the tension upon the brain was released. Again, if the vasomotor control was eliminated by division of the spinal cord above the level of the sympathetic nerves to the abdominal viscera, only the slowing of the pulse was produced, with no increase whatever in the arterial pressure. Cushing's experiments, therefore, tend to show that if tension in the intracranial space is rapidly increased there is produced an anæmia of the brain and medulla. As a result of the approaching medullary anæmia, there is a physiological response represented by a rise in arterial pressure to a point above that of the intracranial tension. In this way a fatal medullary anæmia, which otherwise would be the result of an equalization of the intracranial and arterial pressure, is warded off. The mechanism of this response is attributed to the vasomotor control of the large splanchnic area, which holds the arterial pressure slightly above that in the intracranial space. With exhaustion of the vasomotor mechanism there is an equalization of the intracranial and arterial pressures, following which there is a fall in blood-pressure and respiratory failure in consequence of the resulting bulbar anæmia. Hill,<sup>2</sup> Duret,<sup>3</sup> Cybulski<sup>4</sup> and others have shown that death is not produced until the intracranial pressure equals or exceeds the arterial pressure.

In cerebral trauma several theories have been advanced to explain the

<sup>2</sup> *Physiology and Pathology, Cerebral Circulation*, London, 1896.

<sup>3</sup> *Etude experimentale et clinique sur les traumatismes cerebraux*, Paris, 1878, p. 186.

<sup>4</sup> *Centralblatt fur Physiologie*, 1890, ° 835.

progressive increase in intracranial tension to such a degree that the pressure in the cerebral vessels is overcome and anæmia results. Hill<sup>5</sup> and Bergmann<sup>6</sup> state that as a result of a local increase in intracranial tension there is a complete stasis of blood in the obliterated area. This produces an increased pressure in the vessels of the surrounding areas and causes a transudation of plasma from the capillaries, thus increasing the volume of the compressing body. In this way a vicious circle is established, so that the anæmia may advance until the bulbar centres are encroached upon. According to Courtney,<sup>7</sup> traumata resulting from blows paralyze the cerebral vasomotor centres. This paralysis results in a dilatation of the vessels which they control, producing arterial stasis with a rise in intracranial venous pressure, thrombosis and transudation. As the transudation cannot be absorbed, because of the high pressure in the veins, it further impedes the circulation until complete anæmia results. Cannon<sup>8</sup> attributes the intracranial tension to œdema. Pathological changes are brought about which result in an impairment of the nutrition of the injured area. As a result the tissues undergo changes, producing an increase of the internal osmotic pressure and therefore an increase of water content. The œdematous region compresses the blood-vessels in the surrounding areas, nutrition is again impaired and the osmotic pressure increased, producing further œdema. In this way, the œdema spreads until the cerebral circulation is so encroached upon that anæmia results.

Whatever the correct physiological explanation may be, for an increase in intracranial pressure following cerebral trauma, the agreement is quite universal that fractures of the skull are often accompanied by an increase in intracranial tension and furthermore that this tension frequently rises to such a height that the cerebral vessels are compressed, resulting in anæmia and death. By injecting wax into the cranial cavity, Duret<sup>9</sup> has shown that decreasing the intracranial space by 5 per cent. produced coma and by 8 per cent. resulted in death.

The symptoms resulting from fracture of the skull vary greatly with the severity and location of the intracranial injury. Any force sufficient to break the skull rarely, if ever, fails to injure its contents. Whether or not there is produced gross laceration, contusion or compression, there is at least a change in the physical structure of the brain. The fracture itself, unless depressed, is of very little consequence, so much so that if it were not for the associated intracranial complications, the treatment of this serious injury would be simple. During the past five years in all head

<sup>5</sup> Loc. cit., p. 188 et seq.

<sup>6</sup> *Deutsche Chirurgie, Die Lehre von den Kopfverletzungen*, Stuttgart, 1880, ZZZ, p. 420.

<sup>7</sup> *Boston Med. and Surg. Journal*, 1899, cxi, p. 347.

<sup>8</sup> *American Journal of Physiology*, 1902, vi, pp. 103-121.

<sup>9</sup> *Etude expérimentale et clinique sur les traumatismes cérébraux*, Paris, 1878, p. 86.

injuries we have followed very closely the pulse rate, respiration and arterial pressure, as well as the other symptoms. In many instances, there has been a striking similarity between the symptoms preceding death in cases of fracture and those produced in animals by increasing intracranial pressure to the point of cerebral anæmia. In most cases there has been a history of a fall or blow on the head, producing unconsciousness. If consciousness returns it is frequently lost again, gradually passing into deeper and deeper stupor, then coma from which the patient cannot be aroused. By closely observing the pulse rate and arterial pressure at ten to fifteen minute intervals with the increasing stupor there is observed a slight but definitely progressive increase in the blood-pressure and decrease of the pulse rate. If the injury of the cranial contents is severe enough to cause a great increase in the intracranial pressure, there is produced the characteristic high tension, slow pulse. In the final stage certain typical signs manifest themselves. As the time of death approaches there is stertorous or perhaps Cheyne Stokes breathing, the temperature rises, the reflexes disappear and the patient becomes relaxed. The blood-pressure gradually falls to zero and respirations cease, leaving the running pulse of a vasomotor failure to end the story. The vasomotor mechanism has been unable to maintain the blood-pressure above the intracranial tension and supply sufficient blood to the respiratory centre.

The mortality in fractures of the skull treated by the time-honored expectant method is very high. We believe that frequently death is the result of medullary compression and œdema and that the degree of encroachment upon the vital centres may be ascertained by frequent observations of the pulse rate and blood-pressure. In such cases early relief of pressure is advisable not only to save life, but to lessen the danger of numerous nervous disturbances so frequently seen following fractures of the skull. Not all cases have an associated intracranial tension great enough to produce medullary compression. In some there is sufficient escape of blood and cerebrospinal fluid through a line of fracture to relieve an otherwise fatal compression. These cases do not show the high tension, slow pulse so characteristic of approaching medullary compression, and so operative interference is neither necessary nor advisable. In other cases, the associated laceration or contusion of the brain may be so extensive that a relief of pressure not only fails to avert a fatal outcome, but is an added shock, usually hastening death. There is a group of cases mid-way between these mild and severe types, in which there occurs a progressive increase of intracranial pressure. Unless there is early relief of the tension a fatal outcome is a certainty. We believe that with care this group of cases may be properly differentiated by frequent blood-pressure and pulse rate observations. From these observations one may not only determine the degree of cerebral compression but they may be utilized as an indication for or against the necessity of operation. We do not wait for the appearance of any certain degree of cerebral compression as an indication for operative inter-

ference. Whenever a case of head injury shows a progressive increase in arterial pressure and a corresponding decrease in pulse rate, it is not only advisable, but imperative that immediate relief of intracranial pressure be instituted. If the pressure is not relieved before the dangerous stage of medullary compression occurs, shown by a falling blood-pressure and increasing pulse rate, so much cerebral damage may have been produced that recovery is doubtful.

Barnes and Slocum<sup>10</sup> advise daily lumbar punctures for relief of pressure in fractures of the skull and report a decrease in the mortality during the past three years as corresponding with the previous three years. We have made very little use of lumbar puncture therapeutically, but employ it more as a diagnostic aid. We have frequently observed little or no increase in the pressure of the fluid within the spinal sac, but in the same case at time of operation an enormous increase of intracranial fluid was found. These findings may be explained by a dislocation downward of the brain, blocking the foramen magnum and shutting off the spinal fluid from the effects of tension existent within the cranial cavity.

Whenever relief of intracranial pressure is indicated we have always employed the subtemporal decompression. As most fractures of the skull involve the middle fossa, by this method the meningeal vessels as well as the area where pressure is most dangerous may be directly exposed. The opening in the skull should be large, having a diameter of 4-6 cm. and extend down to the floor of the middle fossa to secure free drainage of blood and cerebrospinal fluid. The temporal muscle and fascia give a firm closure and prevent subsequent herniation.

We have had the opportunity of observing and treating a series of 76 cases of fracture of the skull resulting from acute head injury. Of these cases, 46 were classified as compounds and 30 as simple fractures of the skull. In 17 cases the base alone was fractured and in 22 the vault, while in the remaining 37 cases both the vault and base were involved. The total number of deaths was 26, making a total mortality of 34.2 per cent. Many of the patients who died when first seen were in a moribund condition, having not only a severe head injury, but also other injuries, such as rupture of large viscera and fracture of long bones. If we exclude those patients who died within four hours after admission to the hospital, the total mortality would be 20.6%.

Great emphasis has been placed upon the pulse rate and arterial pressure in the treatment of these cases, although the other symptoms of compression were closely followed. From these observations we have divided our cases into three groups: First, those cases which at no time show any evidence of intracranial pressure; second, cases presenting signs of a definite increase of more or less degree in the intracranial pressure, and, third, those cases which present symptoms of advanced medullary compression or in which there is evidence of severe laceration or contusion of the brain. In the

<sup>10</sup> New York Medical Journal, 1916, vol. 103, p. 309.

first group there were 27 cases. (See Table I.) As in this group there was at no time any evidence of an increase in intracranial pressure, surgical interference was indicated only when the fragments were depressed. We believe that if all depressed fragments are elevated, the danger of many post-traumatic neurological conditions could be greatly decreased. The prognosis as to life is very good in this group, providing infection of meninges and brain tissue is avoided in those cases where the fracture is compound.

TABLE I

## GROUP I

Hospital Number	Age	Sex	Operation	Pulse rate and blood-pressure		After operation		Result
				P.	B. P.	P.	B. P.	
M-76	6	M.	None	108	108	..	...	Well.
101	9	M.	None	84	95	..	...	Well.
M-134	34	M.	Elevation of fragments. Removal of bullet	80	110	85	118	Well.
176	45	M.	None	75	115	..	...	Well.
M-610	12	M.	None	90	125	..	...	Well.
M-634	23	M.	None	92	124	..	...	Well.
507	43	M.	None	88	125	..	...	Well.
178	3	M.	None	140	98	..	...	Well.
187	31	M.	None	100	130	..	...	Well.
286	21	M.	None	90	115	..	...	Well.
359	33	M.	None	78	125	..	...	Well.
465	5	M.	Elevation of fragments	108	92	90	No record	Well.
794	4	M.	None	108	100	..	...	Well.
950	48	M.	Elevation of fragments	No record	...	No record	...	Well.
1153	9	F.	Removal of bullet	84	95	No record	...	Well.
1249	35	M.	None	92	110	..	...	Well.
1603	35	F.	None	84	105	..	...	Well.
1848½	7	M.	Elevation of fragments	90	120	..	...	Well.
2085	61	M.	None	90	135	..	...	Well.
2089	55	M.	None	80	138	..	...	Well.
2388	6	M.	None	85	102	..	...	Well.
2495½	5	F.	None	156	95	..	...	Well.
2308	39	M.	None	72	110	..	...	Well.
2504½	28	M.	None	88	135	..	...	Well.
2805	7	M.	None	110	105	..	...	Well.
2994	35	M.	None	110	122	..	...	Well.
2479	2	F.	None	120	80	..	...	Well.

In five cases operative interference was necessary and of the entire group all made good recoveries.

It is in the second group, those patients presenting signs of a definite increase of intracranial pressure, that we find blood-pressure and pulse rate observations most useful. We believe the degree of pressure as well as the importance as to whether or not the pressure present is increasing may be determined in most cases by frequent pulse rate and arterial tension observations. Thus, these observations are utilized not only to determine the degree

# PULSE RATE AND BLOOD-PRESSURE OF HEAD TRAUMAS

of intracranial pressure, but also as an indication for or against the necessity of operation. If a rapidly increasing intracranial pressure can be relieved before it produces serious damage to the brain, in most cases a fatal issue may be avoided. In some cases the intracranial pressure produced by the

## TABLE II

### GROUP II

Hospital Number	Age	Sex	Operation	Pulse rate and blood-pressure		After operation		Result
				P.	B. P.	P.	B. P.	
706	44	M.	Decompression	54	178	120	125	Death, 24 hours.
1813½	29	M.	Decompression	64	142	No record	...	Good recovery.
160	43	M.	Decompression	70	164	No record	...	Good recovery.
133	40	M.	Decompression	75	180	100	128	Good recovery.
550	17	M.	Decompression	80	145	132	110	Good recovery.
770	37	M.	None	68	135	...	...	Good recovery.
1021	27	..	Decompression	70	145	108	100	Good recovery.
1354	4	M.	None	78	135	...	...	Good recovery.
1368	66	M.	None	60	165	...	...	Good recovery.
1404	56	F.	None	60	150	...	...	Good recovery.
1379	59	M.	Decompression	66	165	84	110	Death, 22nd day, pneumonia.
1544	65	M.	Decompression	70	172	80	124	Good recovery.
1631	35	M.	None	74	152	...	...	Good recovery.
1347	23	M.	Decompression	54	180	104	110	Death 7th day Streptococci meningitis.
119	31	M.	Decompression	50	194	No record	...	Death, 1 hour after operation.
78	54	M.	Decompression	70	148	120	110	Death, 23rd day, pneumococci meningitis.
70	28	M.	Decompression	52	160	102	135	Death 36 hours after operation.
2503	12	M.	None	60	138	...	...	Good recovery.
347	40	M.	Decompression	62	164	120	130	Death 1 hour after operation.
2596	28	M.	Decompression	50	160	90	115	Good recovery.
2090	13	M.	None	70	135	...	...	Good recovery.
2336	68	M.	Decompression	76	155	110	120	Death, 33rd day, pneumonia.
728	8	M.	Decompression	66	135	No record	...	Good recovery.
12	12	M.	Decompression	70	152	No record	...	Good recovery.
264	39	M.	Decompression	42	150	No record	...	Death, 48 hours after operation.
2761	24	M.	Decompression	44	146	60	120	Good recovery.

injury may never reach a degree sufficient to endanger the life of the patient, while in others a fatal compression of the medulla may occur so rapidly that relief cannot be given. Twenty-six, or 34.2 per cent., of our cases presented signs of an increased intracranial pressure, accompanied by an elevation in the blood-pressure and slowing of the pulse rate. (See Table II.) In 19,

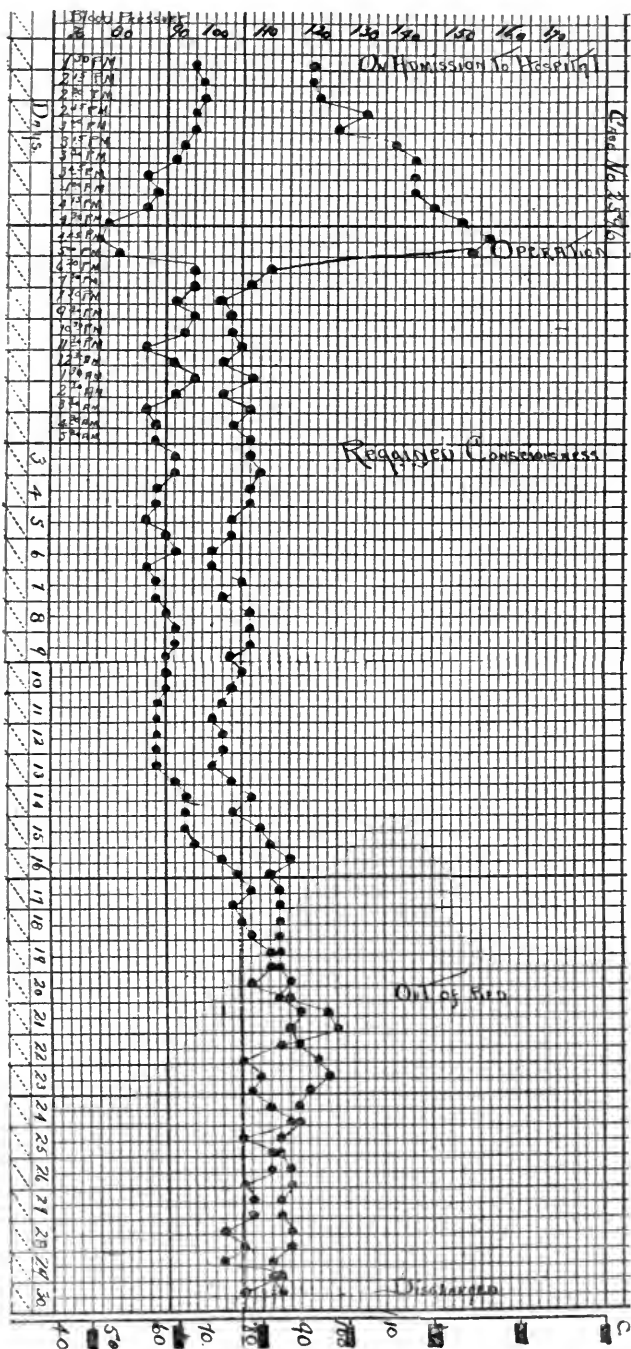
or 73 per cent. of these, the pressure reached such a degree as to endanger the life of the patient and operation was necessary. Ten of the nineteen cases operated upon made good recoveries. Of the nine deaths, two were the result of pneumonia and two died of meningitis. In each of these cases pressure was relieved by operation and they gave every promise of recovery until infection occurred. The patients dying of meningitis—in Case 1379 there was an extensive wound entering the nose and frontal sinus, from which a pneumococci infection of the meninges occurred resulting in death on the twenty-second day. Case 1347 had a very dirty compound wound, and, although every precaution was taken to avoid infection, he succumbed to a streptococci meningitis on the seventh day. In the remaining five cases decompression did not avert a fatal outcome, although at operation all showed evidence of a high grade of intracranial pressure. That there is a fall in blood-pressure and return of pulse rate to normal, as well as marked improvement in general condition, after a high intracranial tension has been relieved can be noted from the post-operative pulse and blood-pressure observations.

*Surg. No. 2596. Simple linear fracture of the skull, vault and base. Intracranial hemorrhage; severe compression symptoms. Subtemporal decompression. Recovery.* This patient, a young man, 28 years old, was admitted to the hospital with the history of falling from a ladder, a distance of ten feet, striking the pavement and injuring his head. When seen in the emergency ward, one hour after the injury, he was semi-conscious, very restless, irritable and screaming in a foreign language. He was unable to give his name or answer any questions intelligently. Bloody cerebrospinal fluid was escaping from his right ear. The pupils were moderately dilated, equal, and reacted to light. There was slight paralysis of the right side of the face. The only external injury was a lacerated wound over the right parietal region, one inch in length and extending down to the aponeurosis. The reflexes were slightly exaggerated and there was no paralysis of the extremities. The pulse was 70 and slightly irregular. Systolic blood-pressure, 125; respirations, 32 per minute. A lumbar spinal puncture revealed a very bloody spinal fluid under little if any tension. At the end of three hours he had become entirely unconscious and could not be aroused. He had vomited once, projectile in character. During this time the pulse rate and blood-pressure observations showed that the pulse rate had decreased to 50 and the blood-pressure increased to 160 (see Fig. 1). The right pupil was greatly dilated and no longer responded to light.

*Operation.*—Right subtemporal decompression. Evacuation of blood clots. Drainage of middle fossa. With the aid of very little ether as an anæsthetic, the usual subtemporal decompression was made on the right side. When the dura was exposed it was found to be blue in color and very tense. There was no extradural bleeding. On opening the dura there was immediately an escape of very bloody fluid, containing several small blood clots. The cortex was blue and tense. A small



FIG. 1.—Showing effect of decompression operation on blood-pressure and pulse rate in case of fracture of skull with intracranial hemorrhage.



spatula was introduced into the middle fossa towards the base of the brain and more bloody fluid escaped as well as three fair sized blood clots. As there was no active bleeding visible, a small cigarette drain was introduced into the middle fossa and the wound closed. The patient stood the operation well and left the table with a pulse of 90 and blood-pressure 105.

During the first 24 hours after operation he was very restless and although very stuporous was able to take some nourishment. After 48 hours the drain was removed and he occasionally answered questions. On the fourth day he answered all questions intelligently. From this time on his convalescence was uninterrupted and he left the hospital thirty days after his injury apparently well.

It has not always been our good fortune to observe an increase in intracranial pressure as in this instance. Most cases operated upon in this group, when first seen, had already developed such a high degree of tension that its relief was necessary immediately. In this case we had the opportunity to observe the development of a fairly rapid increase of intracranial pressure following a head injury, and to note with the usual clinical signs of cerebral compression a definite increase in the blood-pressure and decrease in pulse rate. With the relief of pressure there was a return of the pulse rate and arterial tension to normal on the seventeenth day, as shown in the accompanying chart. The continuation of the bradycardia for a time after operation as shown in this case has frequently been noted. In some cases there has been almost an immediate return of blood-pressure and pulse rate to normal after decompression, but within seven to ten days the slowing of the pulse rate again makes its appearance and in a few cases a moderate rise in blood-pressure occurs. Although no ill effect has ever been noted from this secondary rise in blood-pressure and slowing of the pulse, on several occasions we have used lumbar puncture in an attempt to relieve any pressure that might be present. A similar phenomenon, though less marked, has been noted during the first week in some cases of severe concussion. It is possible that this secondary reaction may be attributed to a slowly forming post-traumatic cerebral œdema as described by Cannon.<sup>11</sup>

Twenty-three, or 30.2 per cent., of the 76 cases, when first seen, presented evidence of an advanced medullary compression or severe brain injury (see Table III). In many of these cases the regulatory vasomotor mechanism had collapsed and was no longer able to maintain the arterial pressure above the high intracranial tension. In other cases the rapidly decreasing blood-pressure and increasing pulse rate showed that the vasomotor mechanism was still making a feeble effort to supply sufficient blood to the bulbar centres. We have seen very few cases recover after the regulatory mechanism of the vasomotor system no longer responds. Hence, the importance of recognizing the degree of encroachment upon the medulla and the necessity of relieving pressure before this late stage.

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<sup>11</sup> American Journal of Physiology, 1901, vol. vi, p. 91.

# PULSE RATE AND BLOOD-PRESSURE OF HEAD TRAUMAS

We have observed a case (Table III, 624) in which there was advanced medullary compression, and although respirations had ceased just before the dura was opened, breathing was resumed with the relief of pressure and the patient recovered. In another case (Table III, 2425) in which respirations had ceased and the compression had advanced to such a degree that

TABLE III  
GROUP III

Hospital Number	Age	Sex	Operation	Pulse rate and blood-pressure		After operation		Result
				P.	B. P.	P.	B. P.	
2205	32	M.	Decompression	52	160	130	90	Death in 2 hours. Gun-shot.
2454	10	M.	Decompression tampon lateral sinus	80	96	76	106	Good recovery.
119	31	M.	Decompression	60	0	140	No record	Death, 13 hours after operation.
1923	3	M.	None	120	80	...	...	Death in 1/4 hr.
60	47	M.	None	120	75	...	...	Death in 2 1/4 hrs.
295	4	M.	Decompression	80	0	130	98	Death 29th day —meningitis.
321	69	M.	None	130	120	...	...	Death in 12 hrs.
624	50	M.	Decompression	72	72	75	115	Well, hernia cerebri.
651	?	F.	None	90	100	...	...	Death in 4 hrs.
740	6	M.	Decompression	90	165	No record	...	Death in 12 hrs.
855	7	F.	Removal of fragments	130	(?)		...	Death in 2 hrs.
865	50	M.	Decompression	110	140	132	128	Death in 24 hrs.
928	61	M.	None	100	112	...	...	Death in 34 hrs.
1014	50	M.	None	0?	0?	...	...	Death in 15 hrs.
1692	10	M.	Decompression	100	115	90	100	Death in 10 days
1726	25	F.	Decompression	95	95	130	125	Death in 3 days
1782	58	M.	None	0?	0?	...	...	Death in 35 min.
2145	43	M.	Decompression	115	155	100	135	Death in 3 hrs
2425	44	M.	None	120?	0?	...	...	Death in 35 min., artificial respiration.
2730	20	M.	Removal of fragments	90	90	...	...	Well, gunshot.
2944	63	M.	None	95	135	...	...	Death, 2 days.
902	33	M.	None	140	70	...	...	Death, 24 hrs.
M-?	46	M.	None	130	100	...	...	Death, 2 hrs.

its relief was considered useless, with the aid of artificial respirations we were able to palpate a feeble radial pulse for thirty-five minutes.

Of the 23 cases in this group, 20 resulted in death, a total mortality of 87 per cent. In 12 cases an attempt was made to relieve pressure by operation, although they presented signs of advanced compression, evidenced by irregular, shallow respiration and a rapid, low tension pulse. Only three recovered, giving an operative mortality in this group of 75 per cent. All the cases in this group that were not operated upon died.

After the dangerous stage of advanced medullary compression has been reached, or in cases when injury to brain tissue is extensive, there is little, if any, advantage obtained by a decompression operation. We are inclined to believe that many of the cases operated upon in this group, if seen to-day, would not be subjected to the added shock of a decompression.

*Summary.*—1. A rapid encroachment upon the intracranial space by any foreign body produces anæmia of the brain and medulla and is associated with a physiological response represented by an increase in the general arterial pressure and decrease in pulse rate.

2. The associated intracranial complications are the dangerous factors in fractures of the skull.

3. When the degree of intracranial pressure equals or exceeds the arterial pressure death results.

4. Frequent blood-pressure and pulse-rate observations not only determine the degree of intracranial pressure, but may be utilized as indications for or against the advisability of relieving the pressure.

5. Intracranial pressure should be relieved before the advanced stage of medullary compression and œdema is produced.

6. The subtemporal decompression is the advisable method for relief of intracranial pressure.

7. By frequent blood-pressure and pulse rate observations fractures of the skull may be divided into three groups: (a) Those cases which at no time show any evidence of intracranial pressure. (b) Cases presenting signs of a definite increase of intracranial pressure. (c) Cases presenting signs of advanced medullary compression or in which there is evidence of severe laceration or contusion of the brain.

The writer wishes to express his thanks to Dr. R. T. Miller, from whose services these cases were reported, and for his help and encouragement in the work.

## FRACTURES OF THE SPINE WITH CORD AND ROOT SYMPTOMS

SOME INDICATIONS FOR AND CONTRA-INDICATIONS TO EARLY OPERATIVE INTERFERENCE\*

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THERE is no question in surgery in which there has been more difference of opinion than the subject of the indications for and contra-indications to operative interference in fresh fractures of the spine with cord symptoms. Just as in the present war the writers on injuries of the spine by bullets and high explosives are divided into two camps,—some advising extreme conservation, others recommending surgical interference in almost all of the patients,—so, in the injuries of the spine which occur in civil life, there are two groups of surgeons, the radicals and the conservatives.

There are certain premises on which all should agree. In the first place, in spite of the cases reported by Harte, Stewart, Coley, and a few others, it seems definitely established that reunion of the divided ends of the spinal cord is impossible, and that, excepting for seeming microscopic efforts at regeneration, no functionally useful regeneration of the non-medullated nerve-fibres in the cord ever occurs.

In the second place, in complete destruction or disorganization of the spinal cord at any level there is an immediate loss of all power and sensation below the level of the lesion with loss of all the reflexes, and with loss of control of the bladder and rectum. After a few hours or days, some of the defensive reflexes may appear, but these should never be confused with true spinal reflexes. In partial lesions of the cord, on the other hand, some motor, sensory and reflex functions are usually preserved.

There are, however, cases of spinal injury, and we see them in fractures of the spine in civil life as well as in the injuries of war, in which at first the symptoms are those of a complete transverse spinal lesion, but in which, after the expiration of days, weeks or months, a considerable or perhaps complete return of power and sensation occurs. These patients suffer either from an injury of part of the cord with concussion, or entirely from spinal concussion, with a resulting nerve block. In the latter condition complete restoration of health is possible.

The crux of the entire matter lies in the question, "Can we distinguish between a physical interruption of all of the cord fibres at any level, and a temporary nerve block due to œdema of the cord or other temporary condition?" Apparently, up to the present time, the clinical differentiation is often impossible, and a large number of surgeons believe, therefore, that exploratory operations are justifiable. These surgeons argue that, if a transverse lesion of the cord exists, the condition is anyway a hopeless one and operative interference will do no harm.

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\* Read before the New York Surgical Society, October 24, 1917.

In recent transverse lesions of the cord the fatal outcome is very apt to be hastened by an operation. In crushing injuries of the cervical cord, especially with high fluctuating temperatures, an operation is almost regularly followed, within a few hours or days, by the death of the patient, and everyone who has operated upon patients of this type has had the experience that the general condition of the patient was much worse after the operation. On the other hand, the evidence that I have been able to collect, both from a study of the literature of the subject and from my own experience, has convinced me that no harm will result from a policy of watchful waiting. If the signs of a complete lesion persist, then the injury is very probably an irremediable one; if, on the other hand, some of the reflexes return, the operation can then be performed, and with a much better outlook for success.

In order to determine that the symptoms are really those of a transverse lesion, more than a modicum of neurological knowledge is necessary. In such a lesion, not only all the varieties of superficial sensibility (touch, pain, temperature) are lost below the affected level, but the deep sensibilities (deep muscle sense, vibratory sense) and muscle tone are also abolished. I do not think that this is the time or place to dilate upon the finer neurological disturbances which have to be looked for, but there is no doubt that more careful examinations than those ordinarily made are necessary before one is justified in making a diagnosis of a complete transverse cord lesion. I do not believe that blood in the spinal canal can ever exert sufficient pressure to cause the symptoms of a transverse lesion.

Root pains are usually absent in complete lesions, but they may be present and be so severe that a laminectomy has to be performed for their relief.

The standpoint to which I adhere at the present time is the following: In cervical and dorsal injuries, with transverse cord symptoms, an operation should never be performed until distinct and definite signs of returning sensation and reflexes give proof that part of the transverse diameter of the cord is intact.

The surgeon must be guided by the results of a careful physical examination and by stereoscopic X-ray plates. Too much attention cannot be given to the smallest details. In transverse crushes of the cord, all reflexes are abolished, and, especially for the first forty-eight to seventy-two hours, not even a defensive reflex can be obtained by irritation of the sole of the foot. The return of the flexor reflex of the great toe and the change of the flexor into the extensor type is of very great significance as an evidence of the transmission of some nerve impulses through the cord. It is very important also to test the deep muscle and bone sense, and the vibratory sense with a tuning fork. Both of these are absolutely lost in complete transverse cord lesions. The tone of the muscles must also be tested; in complete lesions just as in complete division of a peripheral nerve, muscle tone is entirely abolished.

In crushing injuries of the lumbar vertebræ, on the other hand, in which

the roots of the cauda equina are affected, a laminectomy should always be performed as soon as shock has been overcome and after an X-ray picture has been taken. There is considerable experimental and clinical evidence to show that regeneration of divided caudal nerves can occur, and laminectomy and suture of the divided nerve ends should be performed. The injuries of the roots of the cauda equina are very apt to be followed by most distressing root neuralgias and by permanent vesical incontinence. Therefore the nerve roots should be freed from all pressure by a wide decompressive laminectomy, and the ends of divided roots should be united by suture. For these reasons the injuries of the cauda equina should be subjected to early operative interference, no matter how "complete" the symptoms.

*Partial Lesions of the Cord.*—In partial lesions of the cord the problem is an entirely different one. If the injury has not been severe enough to interfere with all of the cord functions, then pressure by dislocated or fractured bone may be contributing very much to the symptoms and the relief of this pressure by a wide decompressive laminectomy is certain to be of great benefit.

The part of the cord that has been irreparably damaged cannot, of course, be benefited, but the compression of a partly crushed cord by bone or blood, or by the intramedullary œdema which follows every cord injury, is certain to cause considerable permanent destruction of nerve-fibres.

The decompressive incision of the cord on its dorsal surface near the posterior median fissure, suggested by Allen, may be tried in those patients in whom the cord is found to be œdematous and swollen. In some of these patients an intramedullary collection of blood can be removed by aspiration with a fine needle, and the harmful effects of an intramedullary collection of blood,—a secondary gliosis or a progressive hæmatomyelia,—can be prevented or reduced to a minimum.

If none of the conditions that have just been mentioned exists, and if the spinal tissue is not compressed by dislocated or by fractured bone, the cord may be angulated or the spinal canal may be much narrowed. The removal of these abnormal conditions by a wide decompressive laminectomy, by the removal of a projecting spicula of bone from the posterior surface of the body of a vertebra, etc., will prevent secondary softening.

Strange to say, there is much more conservatism displayed in these patients, in whom, to my mind, surgical intervention should be instituted as early as possible. Not only are the immediate operative results very satisfactory, but the final results are bound to be better. In these patients with an incomplete crush of the cord, the paralysis and sensory loss below the level of the lesion are not complete; there may be slight sensory but marked loss of motor power; the cutaneous and tendon reflexes may be entirely lost for the first twelve to twenty-four hours; control of the bladder and rectum may be lost at first; there may be continued and agonizing root pains. In many of these patients I formerly believed operative interference should also be delayed—at least for a few weeks. I have, however,

seen secondary softening with all the signs of a complete transverse lesion appear within seventy-two hours, and I have, therefore, operated very early in some of my latest patients. The improvement after these early operations was a striking one, and occurred much more rapidly than in any previously observed cases.

Although there is still much to learn concerning the indications for treatment in fresh fractures of the spine, I believe that, in the present state of our knowledge, extreme conservatism is indicated in the patients with the signs and symptoms of a transverse lesion. The patients with evidences of an incomplete cord lesion should be operated upon very quickly after the injury, unless the signs of interference with function are so slight that no justification for surgical therapy exists, the general condition of the patient is so poor that delay is imperative, or unless the coexistence of other severe injuries precludes operative interference.



# THE SO-CALLED "MIXED TUMORS" OF THE SALIVARY GLANDS

WITH A POSSIBLE EXPLANATION OF THE MORPHOLOGICAL BEHAVIOR OF THE TUMOR CELLS

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IN recent years a large number of specimens of the so-called "mixed tumors" of the salivary and lachrymal glands have been reported. These are very complicated tumors. It is generally agreed that they take their origin in fetal misplacements. They contain elements whose origin has been assigned either to ectoderm, to mesoderm, or to a combination of both these germ layers. The reason for assigning the origin of some of the cells of these tumors to the ectoderm is the morphological appearance of the so-called parenchyma cells. This paper is based upon the study of seven cases and offers a possible explanation of the relationship of these "parenchyma cells" to the stroma cells, especially the chondroblasts.

So far as the clinical features of this series are concerned, they agree with those already reported by others. No age seems free, but the majority appear in young adults. The youngest patient in this series was eighteen and the oldest seventy-six years of age. Four of the specimens occurred in the parotid and three in the submaxillary gland. In gross appearance, the specimens fall readily into four groups.

1. "A group of very fibrous tumors with no mucoid degeneration or cartilage formation.

2. "A group of very hard, dense tumors with large amounts of cartilage and very little fibrous tissue or parenchyma.

3. "A group of soft, very cellular tumors with trabeculae of transparent mucous tissue running in and surrounding the areas of the parenchyma which are yellowish in color and opaque in appearance (parenchyma)" (Wood<sup>1</sup>).

4. Tumors closely resembling carcinomas (Wilson and Willis<sup>2</sup>).

Cartilage is found in three of our specimens and is usually stated as occurring in twenty-five per cent. of all specimens. Series of mixed tumors of this region, however, have been reported by Speese<sup>3</sup> and others in which one-half of the specimens contained cartilage. Osteoid tissue may be found, but true bone is very rare; neither was observed in this series.

Injury does not appear to be an important factor in the development of these tumors. In only one of this series is there a distinct history of injury and this is that of an acute trauma. In this case, occurring in a student, twenty-seven years old, the tumor appeared to follow a kick on the jaw received in a football game.

This series corresponds in general with those reported by others in that metastasis appears rare, while local recurrence is not infrequent. One of our cases had the tumor removed three times and a recurrence was present at the time of death. Even in this case, however, there was no evidence of metastasis.

Microscopically, sections from three of the specimens present in their stroma numerous areas composed of cartilage. In none of the specimens is there found osteoid tissue or bone. All of the primary tumors, except the one specimen falling definitely in the carcinoma group, present a varying amount of mucoid tissue.

In the three tumors belonging to groups 1 and 2, the tumor cells are flattened out and exhibit an attempt to form interlacing or anastomosing tubules lined by a single layer of cells. Apparently due to compression, the flattening has become so pronounced as to make the resemblance of these cells to endothelium quite striking. There is no direct evidence, however, to show that these cells are of endothelial origin. This agrees with the conclusion of Wilson and Willis that "a careful examination of the flattened and distorted cell groups, so frequently interpreted as 'endotheliomas,' leads one to the belief they are either (1) adult epithelium which has been flattened and distorted by pressure, or (2) proliferating embryonic transitional mesothelium which has never attained adult type."

In three specimens the cells of the parenchyma take on a more distinctly epithelial appearance and suggest the normal histological structure of a gland. There is apparently a direct relationship between the amount of parenchyma, the rate of its development, and the degree of malignancy. This is illustrated by one of our specimens, a tumor of the left parotid gland of two and a half years duration, which occurred in a man seventy-six years old. It had in this time attained the size of a small walnut. There is a large amount of mucoid stroma and the parenchyma cells appear flattened, due to compression. The interlacing cordons of parenchyma cells in the stroma gives one the impression of a low grade of malignancy. A recurrence at the end of five months shows an increase in the amount of parenchyma and a decrease in the stroma. Another recurrence removed at the end of the following year shows a tumor composed almost entirely of distinctly epithelial cells.

In one specimen, a tumor of the submaxillary gland, there is such a preponderance of distinctly epithelial cells that it is almost certain that the tumor is a histoid carcinoma of the epidermoid variety. However, the separation from the glandular tissue by an unbroken capsule of connective tissue and the fact that the tumor was primary in the gland are the obstacles encountered in making such a diagnosis. The patient died one year later with an extensive recurrence.

As to the theories of the origin of these tumors, Wood concludes, "The complicated structure of the stroma, containing as it does elements such as embryonic connective tissue, cartilage, bone, fat and lymphoid tissue, and very rarely striated muscle, is explained most easily by the assumption of an embryonic misplacement of mesoblast. The structure of the parenchyma is so slightly characteristic in morphology that its epithelial nature in all cases can only be considered as probable; yet in about 24 per cent. of the tumors examined the presence of epithelium is undoubted. The form and relationship of the cells of the parenchyma do not furnish sufficient data to justify these cells in being regarded as of epithelial origin." Speese<sup>3</sup> feels warranted in concluding that the parenchymal cells of these tumors are in

part, at least, epithelial. Verhoeff,<sup>4</sup> from a study of five cases of tumor of the lachrymal gland, states his opinion as follows: "The mixed tumors of the lachrymal and salivary glands (so-called endotheliomas) are essentially epiblastic in origin. The stroma of these tumors is derived from mesoblastic cells misplaced from other structures, but is probably produced by an atypical development of cells which ordinarily would have gone to form part of the stroma of the normal gland."

Martini,<sup>5</sup> in a discussion of six cases which he reported, thinks he can trace the origin of the tubules and cell formation of the parenchyma from proliferated endothelium. Wilson and Willis conclude that, "There is considerable evidence to support the theory that these tumors are mesotheliomas of embryonic origin."

It is apparent from these quotations and the writings of others that the difficulty in assigning an origin to these tumors is in the behavior of the so-called parenchyma cells. At times they appear as of epithelial and again as of endothelial nature. The presence of these cells has been explained by postulating an inclusion or rest of mesoblastic tissue early in the development of the gland or by the inclusion or rest of epiblastic tissue.

The authors are of the opinion that a simpler explanation of these new-growths is at hand, if one takes into consideration that the derivation of some of the head cartilages can be ascribed to epithelium. One of the authors in collaboration with F. L. Landacre<sup>6</sup> has demonstrated that cartilage in the urodeles can be derived from epithelium. This fact, strange as it seems, is not a mere hypothesis but can be convincingly demonstrated. It is not a new observation, but a confirmation of work which dates back as early as 1878 when Marshall<sup>7</sup> recognized that some of the epithelial cells of the neural crest in the head region went into the formation of mesenchyme, but could trace them no further. This idea was gradually enlarged upon until, in 1893, Miss Platt<sup>8</sup> made the statement that the branchial cartilages in necturus are formed from cells whose origin could be traced back to ectoderm. This fact, in part or in whole, has been confirmed by a number of investigators, including Kupffer,<sup>9</sup> Lundborg,<sup>10</sup> and Dohrn.<sup>11</sup> Like any other scientific fact, it has been rejected by some but largely by those of the older school of embryologists who held to the theory of the integrity of the germ layers. This work has not been confined to any one type or class of the vertebrate series, but includes some of the fishes, amphibians, and even in birds it is known that some of the epithelial cells of the neural crest do not go into the formation of ganglia, but are differentiated into mesenchyme. Confirmation of this subject is still lacking in the mammals and probably will be on account of the absence of certain conditions of cellular morphology such as the existence of a large amount of yolk and presence of pigment granules which is necessary to trace and recognize the mesenchyme formed from ectoderm. We are, nevertheless, of the opinion that there is a possibility if not a probability that there is in the head and branchial region of the human embryo mesenchyme which has been derived from ectoderm. Later this may differ-

entiate into cartilage and possibly into other derivatives generally assigned to mesenchyme derived from endoderm.

Assuming then that this hypothesis is tenable, it gives a ready explanation of the morphological behavior of the tumor cells in these mixed tumors of the salivary glands. If these tumors arise from an inclusion or misplacement of mesenchyme derived from ectoderm, all the tissues found can be accounted for at once. Either the cells fail to differentiate and simulate the cells from which they arose, or they differentiate along the lines they normally do and form connective tissues, cartilage and sometimes bone.

*Summary.*—From a study of seven specimens of the so-called mixed tumors of the salivary glands, it seems probable that there is in the head and branchial region of the human embryo mesenchyme which has been derived from ectoderm, and that inclusion or misplacement of this ectodermal mesenchyme gives rise to the so-called mixed tumors of the salivary glands.

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## HYGROMA COLLI

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HYGROMA colli is relatively rare. The careful collective investigation of international literature made by Dowd<sup>1</sup> in 1913 makes a review of the subject superfluous. To his compilation of 91 cases he has added 3 others. Since then a like case has been reported by Smith<sup>2</sup> and later another by Cameron.<sup>3</sup> It is the purpose of this report to place on record an additional case which recently came to Dr. Kahn's care in the Children's Hospital.

The patient, a healthy looking girl of seven years, was brought because of a disfiguring tumor of the right side of the neck (Fig. 1). There was nothing in her family or personal history that would be considered noteworthy save that when eleven months old she fell from a table. When thirteen months of age the growth, the size of a guinea egg, was first detected by the parents, who, thereafter, closely observed its gradual enlargement. It was never tender and at no time showed inflammatory signs. When the child was two years old the tumor, having attained the size of a chicken egg, was drained by an incision which, quoting the parents, "spurred blood." Prompt healing of the wound was followed by reappearance of a steadily growing tumor.

*Local Condition.*—When admitted to the hospital there presented over the posterior triangle of the neck a conspicuous ovoidal tumor about the size of a goose egg, the fundal end extending downward to the clavicle. It was painless, soft and fluctuant, incompressible, without impulse and seemingly unilocular. The overlying normal skin was not adherent and bore no visible evidence of previous operation. No enlarged lymph-nodes were palpable. Translucency test and exploratory puncture confirmed the cystic character of the growth.

*Operation.*—A straight incision over the long axis of the tumor exposed a thin-walled cyst. Its pressure had so thinned the sternomastoid and trapezius muscles that their contiguous borders were poorly defined. No special difficulty was encountered in dissecting the cyst from its bed except at the upper part, where it was intimately adherent to the triangle floor. Under the posterior border of the sternomastoid and closely connected with the cyst was a smaller one, the size of a pecan. It was more deeply embedded in the neck and its amber hue contrasted with the pale blue color of the larger cyst. In its excision the thin wall was nicked, but the drainage of its straw-

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<sup>1</sup> Dowd: ANN. SURG., 1913, lviii, 113.

<sup>2</sup> Smith: Jour. Am. Med. Assn., 1914, lxii, 522.

<sup>3</sup> Cameron: Canad. Med. Assn. Jour., 1916, vi, 137.

colored, serous contents caused no perceptible reduction in the size or tension of the adjoined cyst, giving the inference that their cavities did not communicate. The growth was completely extirpated, the larger cyst being removed intact. There was no obvious attachment to any vessel and hæmostatic ligatures were unnecessary. With a continuous horse-hair suture the skin wound was closed. A small rubber band for drainage was left in its lower end. Subsequent healing was without incident.

*Pathological Report* (Dr. Graves).—Gross description: Specimen consists of thin-walled cyst, measuring 3 x 6 x 8 cm. as it lies on board. It is covered with tags of fibrous tissue between which wall is pale blue. By transmitted light contents are translucent and pale pinkish red. Cyst fluctuates and appears to be unilocular. At one side is an area about 2 cm. in diameter which is smooth, pink and glistening and around which are remains of wall of cyst, the smooth area apparently being a part of wall of same emptied cyst. Surgeon states this was opened at operation and thin, straw-colored fluid escaped. After fixation for museum, cyst is opened and found to be unilocular, with a smooth, pale lining.

*Gross Diagnosis*.—Multilocular hygroma.

Microscopical description: Sections of small punctured cyst show thin wall of fibrous tissue. Outer surface bears fat and some fragments of muscle. Inner lining has been rubbed off, making it probable that it was endothelial rather than epithelial. Sections of larger cyst show an endothelial lining.

*Microscopic Diagnosis*.—Multiple hygroma colli.

*Comments*.—These multilocular, serous, cervical cysts in children are probably due to distention of embryonic sequestrations of lymphatic tissue. They are usually lined with endothelium. They have the power of persistent, irregular growth. Trauma, in some cases at least, seems to be a decided factor in stimulating this growth. Their inherent power of development is sufficient to force themselves into surrounding structures. In multilocular hygroma the serum in one compartment may be clear, while in an adjacent one it may be tinged with hæmoglobin. After birth the growth may show a capricious enlargement with no tendency toward spontaneous recovery. The aggregation of cysts, although presenting superficially, originates beneath the deep cervical fascia and most often appears in the posterior triangle of the neck. In the submaxillary region its clinical differentiation from branchial cyst is not always easy.

After partial removal the tumor has, according to Murphy, returned with enormous increase in size and secretion. This assertion, together with Bloodgood's observation of late malignant development, indicates that the proper treatment of cystic hygromata is early, clean and complete removal.



FIG. 1.—Child showing hygroma of neck.



FIG. 2.—Exterior of larger cyst with inner surface of base of smaller cyst facing.



FIG. 3.—Interior of opened larger cyst.



## PULMONARY TERATOMA

REPORT OF A CASE WITH REMARKS ON OVIGENOUS TUMORS \*

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THIS is a report of a case of pulmonary teratoma operated by ourselves at the Spartanburg Hospital, followed by a discussion of the present state of knowledge concerning teratomas and dermoids in general, their origin, pathology, symptomatology, diagnosis, prognosis and treatment.

In the lung teratomas are very rare, and until recently little was known concerning them. Unfortunately, at present little can be done that is permanently remedial, but further study and wider experience may soon enlighten the subject.

An adult white male, aged forty-six, native of North Carolina and planter by occupation, presented himself on June 12, 1915, at the Spartanburg Hospital, for diagnosis and treatment.

His family history was negative as was his personal history, save for an attack of measles during childhood and a typhoid infection at twelve. He had always lived a fairly regular life and, although he smoked and drank occasionally, he positively denied the venereal infections.

His chief complaints were persistent soreness through the left chest, occasional cough and some dyspnoea. These he attributed to a blow from a falling tree, received ten months previously.

The chest showed slight respiratory diminution over the left side anteriorly, yet the chest was apparently symmetrical in contour. There was no venous distention nor oedema of the neck. Palpation revealed diminished vocal resonance over the left chest front and back, more marked over the latter.

Anteriorly the left lung was fairly resonant throughout, but posteriorly from the fifth to the eighth interspace there was a decided degree of dulness and over this area the breath sounds were absent. The right lung was clear and rather hyper-resonant throughout.

There was no visible or palpable cardiac impulse. The apex thrust was not visible, yet its sound was heard best in the fifth left interspace two inches inside the nipple line. There was no thrill nor shock. The heart sounds, though regular, were but faintly audible. There was no murmur, but the pulmonic second sound was slightly accentuated. The pulse was regular, of fair volume, eighteen to the quarter, and not sclerosed. Physical examination otherwise was negative.

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\* Read before the South Carolina Medical Association, April, 1916.

The supposition was that there was an area of consolidation of fluid in the left lung situated more nearly the posterior than the anterior chest wall.

On the following day an aspirating needle was inserted through the sixth left interspace just behind the posterior axillary line and 30 c.c. of blood-tinged yellowish serum were obtained. Smears and cultures made from this fluid showed no microorganisms, but a few endothelial cells.

The patient's chest was skiagraphed and a large, round shadow in the left lung showed on the plate.

June 26 the patient was sent to the Jefferson Medical College Hospital, where again he was tapped, skiagraphed, fluoroscoped and studied clinically by Professors J. C. DaCosta and H. A. Hare. The diagnosis remained uncertain, but operation was advised. He refused and returned to his home. He came to us again and was given five X-ray treatments, after each of which he complained of great pain and was troubled with increased cough. Another skiagraph showed that the diameter of the shadow had increased one-half inch. He left the hospital, but returned on July 28, requesting that the operation be performed, because of an increase in the soreness, in the frequency of the cough and because of an impairment in his speech.

On the following day he was etherized and three sides of a quadrangular flap were dissected upward and turned backward over the vertebral column from above the sixth to just below the eighth rib. The subjacent muscle fibres were divided and two inches of the sixth and seventh ribs were removed. The pleura immediately bulged and pulsated. It was greatly thickened and evidently adhered to the lung. As a precautionary measure it was stitched to the lung by two chromic catgut sutures one and one-half inches apart. The cautery was carried inward between these two points and a considerable amount of yellowish serum exuded through the opening thus formed.

The finger was inserted, the tip of which barely reached the anterior wall of the cavity, where the beat of the heart could be easily felt. A number of pieces of whitish cheesy material were removed. The cavity was partially dried and drained by rubber tubing and iodoform gauze carried through a fenestrum in the flap which was sutured back in place. The wound was cleansed and dressed and the patient was returned to his room in good condition. He reacted well from the ether and the operation and, though the wound continued to drain freely, he was in due time up and about the hospital. The wound was irrigated frequently with varying percentages of stimulating solutions. Drainage continued.

He gained some weight and felt much better. On August 28 he left the hospital, but remained under the care of his family physician who dressed the wound daily. The drainage almost ceased, only to reappear a few weeks later, increased in amount and rather foul in odor. He ran a noonday temperature of a degree or a degree and a half and had chilly sensations at frequent intervals. His strength gradually waned; both eating and talking intensified the cough and he complained a great deal of pain in the left chest which frequently radiated down the corresponding arm and occasionally extended to the left hip.

## PULMONARY TERATOMA

During the third week of November he had a hard spell of coughing, spat up considerable blood and more still appeared on the dressings. Another week passed, and he had another hemorrhage from which he rallied slowly, having been rendered unconscious for nearly three hours.

On December 8 he was again fairly cheerful, ate his usual supper, and retired for the evening. He was asleep but an hour when he developed a severe paroxysm of cough and died a moment later in a deluge of blood.

Sections of the tissues removed at operation were stained and studied by Dr. W. M. L. Coplin, Professor of Pathology at the Jefferson Medical College, who made the diagnosis of pulmonary teratoma. Autopsy was not obtained, but more tissue was secured from the lung at the time of death and Dr. Coplin again reported pulmonary teratoma, sections of which also revealed the presence of a few carcinomatous cells.

*Remarks.*—Teratomas are commonly solid neoplasms, although not infrequently cystic and contain epithelial and connective-tissue elements. Dermoids practically always are cystic and with one exception are congenital in origin. They spring either from embryonic cutaneous inclusion or from the growth of a misplaced and blighted ovum. When not congenital they develop from nests of epithelial cells that were carried into the deeper tissues during the inception of a punctured wound. Both these tumors may be classified, therefore, as being congenital or acquired in point of origin and as being external or internal in point of location. A few examples of external teratomas are the well-known historical Siamese twins, polydactylism, spina bifida or monogerminal teratomata and the so-called foetus in fetu or bigerminal teratomata.

A single ovum maturing in the normal manner, but for the presence of an excessive face, head, extremity, trunk or pelvis, though rare, is, nevertheless, occasionally seen and is explained by the theory of dichotomization; which in substance is, that in animals there is a tendency for parts ending in free extremities to bifurcate. If the digits are affected, supernumerary fingers or toes are formed, whereas if the dichotomization process extends to the axis of a limb or to the axis of the trunk, two limbs or two trunks more or less perfectly formed are the inevitable result.

The internal teratomas are far more frequent and are the types usually in mind when the term is used.

Dermoids are distinctly more common than both types of teratomas combined.

These morbid processes are usually unilateral, often slow in growth, commonly small in size and, as a rule, are without characteristic symptoms or pathognomic signs. If there be an orifice through which from time to time there emerges a hair, a particle of bone, a piece of cartilage or a varying amount of glandular secretion, the nature of the underlying condition is at once suggested. Physically they are usually firm, occasionally soft, frequently dough-like and sometimes tense and bulging.

Dermoids are made up largely of dermal tissue, plus one or more of its appendages, whereas teratomas are tumors of a peculiar mixed histologic composition (Hilton) and are described by some as containing tissues, organs or systems of organs derived from two or all of the germ layers.

Christian in 1907 spoke of dermoids as structures of slight complexity and of teratomas as structures of great complexity, implying thereby that the latter are composed of a greater number of germinal layers than are the former. The ovary occupies the first, the testicle the second, the sacrococcygeal region the third and the mediastinum the fourth position in point of frequency for the growth of these tumors.

In fact, so rare are they in this last-named space that Hare, in 1888, when reporting a collection of 520 cases of mediastinal tumors or accumulations, only found eight dermoids and one unquestionable teratoma. Since then others have been reported and Christian, in 1907, analyzed seventy cases, of which seven were teratomas and the remainder dermoids.

Among the rarer and more superficial sites for these morbid processes are the outer borders of the temporal canthi, the line of the thyroglossal duct, the region of the facial and the branchial clefts as well as the site of any previously received punctured wound.

In the words of Moschcowitz, "cystic swellings at the outer angle of the eye are usually dermoids," and one should further remember that they frequently are connected to the cerebral envelopes through a small opening in the underlying cranial bone.

Histologically they are composed of two or more of all the known tissues. Unstriped muscle fibres, fat, bone, cartilage, dentin or epithelial cells of a type peculiar to the skin or mucous membrane from which they were originally sequestered, are frequently found in these masses. Christian discovered neuroglia in three of the specimens he studied. In the ovarian and post-anal teratomas unquestionable mucous membranes have been demonstrated and areas of thyroid and mammary gland tissues have been described in teratomas situated far distant from these organs.

But little has been written concerning the so-called teratoma strumosum thyroideale ovarii, or teratomas of the ovary with perfectly normal histologic thyroid tissue scattered here and there diffusely through the meshes of the ovarian gland. According to Norris, there are but thirteen positive cases on record. Some histologists have called it a metastatic thyroid carcinoma even in the absence of any recognizable malignant change in the thyroid gland itself. Others have termed it endothelioma, but the microscope does not substantiate this term, and though it may be a colloidal degeneration of an adenomatous ovarian area, it more nearly corresponds to the accepted definition of a teratoma and as such should be so designated.

Clinically, Norris observes that they are of rapid growth, inducive of adhesions and ascites, provocative of painful and irregular menstrual flows, incident to both primiparas and multiparas, and that no case of bilateral involvement has been reported. The thyroid gland may or may not be

enlarged. They are prone to become malignant, if not already so, but the probability of a surgical cure is better than if it were an unquestionable carcinomatous infiltration.

In the ovaries these ovigenous tumors have much the same morphology as when situated elsewhere. Much has been written of them. The surgical essence of ovarian cysts and tumors in general is extirpation. When one recalls that twenty per cent. of all ovarian cysts are malignant and that twenty per cent. more are potentially so, it behooves the attendant to advise removal of all enlarged ovaries due to new tissue formation of whatever origin.

In the testes and the inguinal canals these morbid entities necessitate differentiation from hydroceles, abscesses, hæmatomas, hernias, undescended testicles, hæmatoceles, benign and malignant tumors and granulomas of a luetic, tuberculous or actinomycotic origin. They should be removed. The perirectal and sacrococcygeal regions, from their embryologic origin and subsequent evolution, attendant as they are with so many developmental defects and "narrow escapes from the same," are peculiarly susceptible to their formation.

In these regions they are round, smooth, encapsulated, sessile or pedunculated. The symptoms produced vary with their anatomic relations and the size of the growth. Within or immediately around the rectum they cause a sensation of pelvic fulness and painful or difficult defecation. An occasional hair may be passed. Blood and pus, or glandular secretions in the fæces, are absent unless there is some ulcerative or destructive process taking place.

Dermoidal sinuses are not infrequent over the sacral bone. They show as small orifices which heal and break down again and again over a long period of time. They are always in the median line. One or more hairs not infrequently emerge from the orifice. Such sinuses demand a wide circular incision down to and even beyond their base. Remove the entire channel. Cauterize or carbolize any outlying cells. Pack the cavity thus formed with plain or iodoform gauze. Do not sew it up.

Teratomas and dermoids situated in front of the sacrum are frequently attached to it by a pedicle. They vary in size from a pea to a man's head. They may remain at their site of development or they may extend forward and show in the perineum. Occasionally they push upwards into the abdomen and even more rarely they dissect downwards and hang between the legs.

The cutaneous coverings of these tumors here, as elsewhere, may be thin, thick, discolored or inflamed. The entire structure is peculiarly susceptible to infection which frequently leads to rapid suppuration. The parturient mother may, through her own efforts at expulsion of her babe, tear the sac or infect its contents.

Sir J. Bland Sutton observes that these tumors in the mediastinum originate from cutaneous and subcutaneous inclusion of cells, with their subsequent dislocation backward, during the process of folding together of the two halves of the body during early intra-uterine life.

Though these cells may manifest themselves later in life as a tumefaction within the sternal bone or beneath its periosteum, they far more frequently are carried further inwards to settle in the anterior mediastinum. Here they involve its contents in the meshes of their structure, and striking anew for further fields of conquest, hurl themselves on to the pericardium or on to the pleuræ and having penetrated one or the other or both of these coverings, attack their enclosed viscera. Strangely enough the heart itself seems to be peculiarly free from invasion.

Pulmonary teratomas originate therefore, *not in the lung itself*, but in the mediastinum, to which place they were primarily conveyed from some portion of the thoracic wall.

Once in the lung itself, they frequently communicate with a bronchus, and coming in contact with the germ-laden air are prone to suppurate. More rarely still they cause anxiety by the presence of a hair or some other epithelial appendage in the expectorated material.

Symptomatically there is nothing specific. One or more of all the classical intrathoracic symptoms may be present, depending upon the size and location of the mass.

Pain, cough, dyspnœa, cyanosis, hœmoptysis and articulatory disturbances may be present. Frequently a sense of fulness is complained of. Shaw believes that they differ from pulmonary neoplasms by the absence of cervical œdema and venous distention. On physical examination may be found one or more of all the signs of a pulmonary mass usually revealed by inspection, palpation, percussion and auscultation.

Neither the X-ray nor the fluoroscope identify, in the absence of teeth or bone, the nature of the process.

Clinically, one must eliminate the ordinary benign and malignant neoplasms, gummata, sacculated or button-hole aneurisms, pulmonary abscesses, encysted empyemas, hydatid or echinococcic cysts, tuberculous and actinomycotic granulomas before the diagnosis of pulmonary teratomas or dermoids can be made.

The diagnosis having been or not having been definitely settled, the question of treatment next presents itself. The method of procedure will vary with the age and comfort of the patient, the size and location of the mass and with the experience and judgment of the surgeon. In the presence of signs and symptoms that warrant surgical interference the prime object is, of course, to remove the mass *in toto*. This has been successfully performed in but one case. If the mass is so inaccessible as to prevent such accomplishment and yet is sufficiently large to impede circulation or to impair respiration, the chest is to be trephined and the cyst incised that it may freely drain. The cavity then should be irrigated as indicated with a stimulating solution of iodine, copper sulphate, lysol or a two per cent. solution of aluminium acetate. Even then usually the best that results is the formation of a fistula which persists as a rule until death occurs from some intercurrent disease or complicating condition.

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This explains why such growths should always be let alone until they are seriously interfering with the physiologic functions of the intrathoracic viscera.

Drugs, of course, are of no avail save the opiates, which modify the pain. It is doubtful if any such case has been cured by the X-ray or by the application of radium. This leaves the surgeon, therefore, with the knife and cautery as his weapons of choice for allaying or prolonging the inevitable end which occurs in practically all cases of pulmonary teratoma and dermoids whether they be operated or non-operated.

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## GASTRODUODENOSTOMY: ITS INDICATIONS AND TECHNIC

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GASTRIC surgery has attained its present high place as a result not only of the impetus received from the early contributions of American and English surgeons but also from an increasing coöperation between clinician, röntgenologist and surgeon, the investigation of the causes of past failures, a clearer conception of the indications for operation, the more careful observance of general surgical principles, and, particularly, a more intelligent appreciation of the specific merits of the many technical procedures, old and new, which are at the disposal of the surgeon in the treatment of benign gastric and duodenal lesions. Further progress can well be expected as the experience of those who are particularly interested in the subject of gastric surgery becomes available, and it is with this in mind that I draw attention to the operation of gastroduodenostomy.

Gastroduodenostomy is not an infrequent operation, inasmuch as the various types of pyloroplasties (Finney, Heinicke, Mikulicz, etc.) are essentially anastomoses between stomach and duodenum. The operation to which I have reference does not include in its technic any interference with the pylorus, nor does it utilize the ulcer callus as any part of the posterior wall of the anastomosis. In other words, the ulcer area is purposely avoided and the anastomosis is made entirely in healthy tissue.

Historically, the operation of gastroduodenostomy is of some interest.

Moynihan credits Jaboulay as the first to suggest and carry out gastroduodenostomy (1892 and 1894). Many modifications of this principle have been proposed. Kümmell divided the duodenum, closed the proximal end, and implanted the distal into the anterior wall of the stomach near the greater curvature. Billroth, Villard, Terrier, and Kocher devised other methods of accomplishing the operation. Kocher advised an elaborate mobilization of the duodenum (the descending and a considerable portion of the transverse portion) by dividing the parietal peritoneum covering the kidney. The operation he named "lateral gastroduodenostomy." In this country by far the most popular form of this principle has been the pyloroplasty of Finney, an operation which has the advantage of permitting, under certain conditions, the safe excision of the ulcer, as well as making possible the inspection of the mucosa in the immediate vicinity of the pylorus.

It is important to become familiar with these various methods and to know their indications, for only with such knowledge will the error of forcing a favored operation to apply to unsuitable conditions be avoided.

The circumstances we have recognized as justifying a gastroduodenostomy of the type described in this paper are as follows:

1. A pyloric lesion or a lesion involving the pylorus, associated with marked obstruction, with more or less ballooning of the duodenum pro-





FIG. 1.—High lying duodenal ulcer causing an angulation which brings the upper duodenum and the pyloric end of the stomach in close apposition. Gastroduodenostomy made below ulcer and ulcer covered. See Fig. 2.

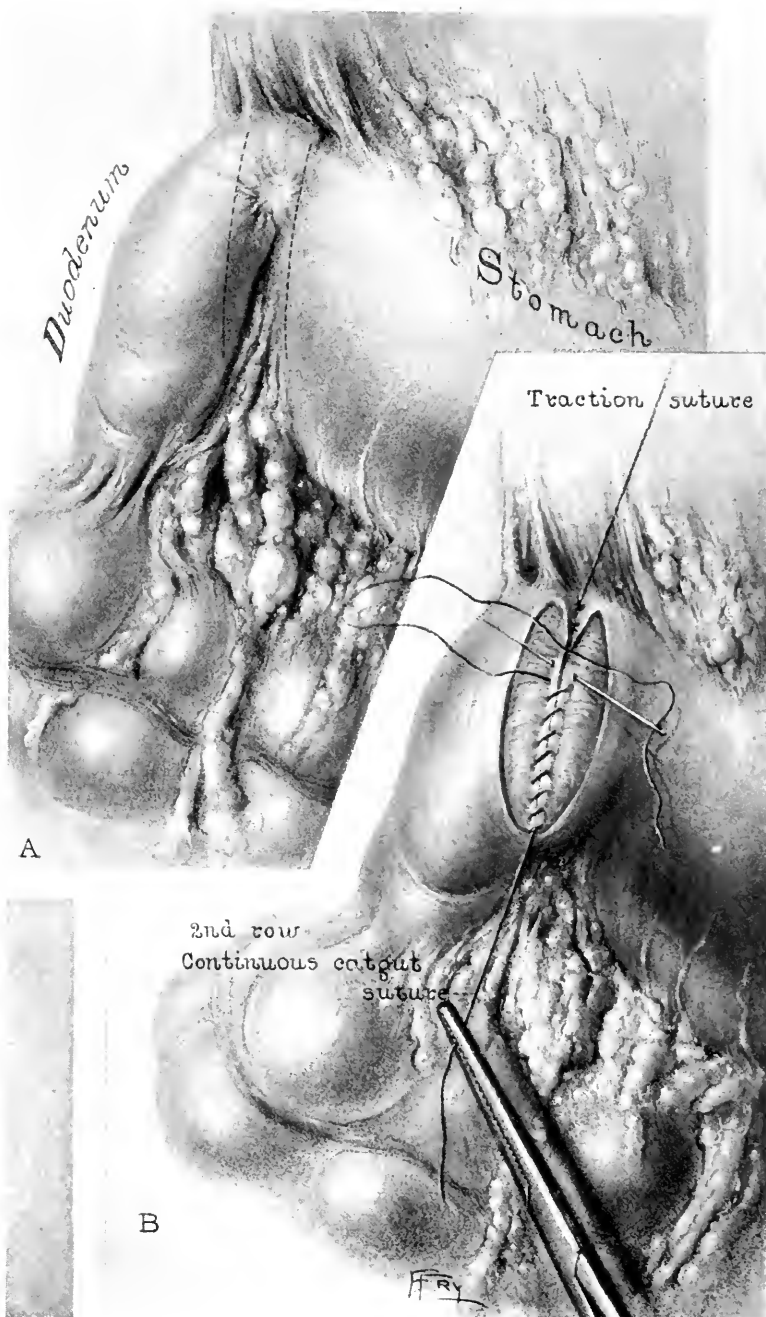


FIG. 3.—A, easily mobilized duodenopyloric ulcer. Gastroduodenostomy made in front of the ulcer.  
B, gastroduodenostomy in progress.

## GASTRODUODENOSTOMY

ducing a deformity the counterpart of an hour-glass stomach (Figs. 1 and 2). Particularly if such a lesion is active or has caused the pylorus to become fixed to pancreas or liver, or in a mass of adhesions, should the advisability of gastroduodenostomy be taken into consideration. At the same time we would still give posterior gastrojejunostomy the preference in this group, with gastroduodenostomy as an excellent alternative, reserving the latter as the operation of choice in the groups to follow.

2. Any condition such as those indicated in Group 1, complicated by anatomical derangements (either congenital or the result of previous inflamma-

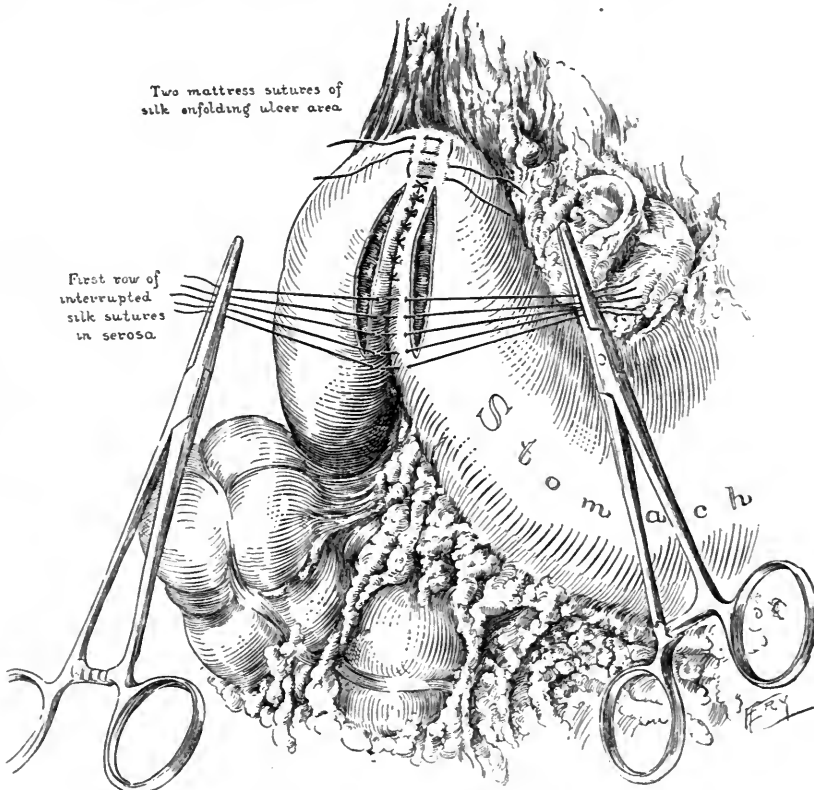


FIG. 2.—Gastroduodenostomy for obstructing ulcer with an angulation. See Fig. 1.

tory exudate) of a nature to preclude or make inadvisable a posterior gastrojejunostomy.

3. In those instances in which patients have failed to obtain the expected relief from gastrojejunostomy because of secondary complications, such as gastrojejunal ulcer and mechanical difficulties, because the operation was ill-advised or improperly done, or because of unknown reasons, gastroduodenostomy has been of signal value following the cutting-off of the gastrojejunostomy and the restoration of the walls of the stomach and jejunum.

It should be mentioned that the lesion in these various conditions, as far as can be determined, is a chronic ulcer, that it is not safely excisable and that

conditions are such that a pylorotomy is not justified because of the operative risk.

The operation we have carried out is as follows:

The best possible exposure and mobilization of the pyloric end of the stomach and duodenum is obtained. In many cases this exposure is already strikingly in evidence, while in others much aid may be gained from the careful division of the adhesions which course over the prospective field of operation. Markers are now placed close to the inferior border of the duodenum and stomach at such points as to insure, when approximated, a sufficiently large anastomosis. A line of interrupted sutures of fine silk are placed posteriorly, parallel to the pylorus, and usually immediately in front of the scarred tissues. A continuous suture of fine chromic catgut is placed in front of the silk suture, extending slightly above and slightly below the proposed opening. The stomach and duodenum are now opened, actively bleeding vessels separately ligated, and the anastomosis made just as in a gastrojejunostomy with No. 2 chromic catgut (Fig. 3). The posterior suture lines are now duplicated anteriorly, *i.e.*, a row of fine chromic gut and finally a few interrupted sutures of silk. No clamps are used, but contamination, although not possessing serious possibilities, is largely avoided by careful isolation of the operative field and by suitable wound protection.

The operation under good circumstances is easier and can be done in less time than a posterior gastrojejunostomy. In other cases, however (usually when the operation is not one of choice), exposure is difficult on account of the deeply placed and fixed pylorus, but even in these unfavorable cases the results of the operation and its adaptability to specific conditions have been exceedingly satisfactory.

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# TECHNIC OF OPERATION FOR REPAIR OF THE ILEOCÆCAL VALVE

WITH SUMMARY OF THE RESULTS IN A SERIES OF TWENTY-SIX CASES

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IN the November issue of *Obstetrics, Gynecology and Surgery*, 1913, I presented a paper describing a method for repairing the incompetent ileo-cæcal valve and also a method for making an artificial valve. The purpose of this paper is to present additional points relating to the technic of the operation for repair of the ileocæcal valve and to present a brief summary of the results in a series of twenty-six cases in which the valve was repaired in connection with some other operation requiring abdominal incision.

The operation for repair of the valve is exceedingly simple in principle but requires delicate manipulation and an exact and careful technic in execution. It is obvious that obstruction may be produced by a faulty technic and the patient's life may be imperiled.

The thoroughgoing X-ray examination which reveals the incompetency of the ileocolic valve will also almost certainly disclose other lesions, such as prolapse and adhesion or incarceration of the pelvic colon, a common cause of incompetency. As clear an idea as possible of the conditions present must be gained by other modes of examination and by a careful clinical study of the case so that the incision may be made at a point from which the several lesions present may be dealt with if advisable.

If obstructive adhesions of the pelvic colon exist, the incision will be made in the median line so that both lesions may be dealt with from the same opening. If there is reason to believe that the gall-bladder is affected, or that lesions exist at the hepatic or splenic flexures, the incision should be made at about half an inch to the right of the median line and will be four or five inches in length, the junction of the upper and middle thirds of the incision falling opposite the umbilicus. An incision at this point makes it possible to deal with the ileocæcal valve or the appendix and to inspect the stomach, the gall-bladder and the hepatic flexure of the colon.

The principle of the operation is simply the restoration of the valve by invagination into the colon and constriction of the lumen of the widely stretched ileocolic junction to its normal size. Both things must be done; neither one alone will repair the valve.

In the normal subject the ileocecal valve consists of two folds so placed that the slit-like opening between the folds lies transversely in relation to the horizontal axis of the large gut. The object sought is to restore these folds by invagination of the ileum. The operation may involve the restoration of either the upper or the lower segments of the valve or both.

With the cæcum and a few inches of the ileum drawn out through the incision and properly disposed, it is generally easy to see on the anterior face of the gut close to the upper side of the non-vascular fold of Treves (ileocæcal fold) the line where the ileum joins the colon. From this point the junction may be easily traced for two or three centimeters along the upper border of the ileocolic opening, but beyond this point it is usually covered and obscured by a plexus of tortuous veins which are sometimes buried in fat.

The lower half of the junction, beginning at the non-vascular fold of Treves, generally comes fully into view as soon as the fold is lifted and turned upward. Not infrequently, however, the fold of Treves is fixed by adhesions to the cæcum, the ileum or the appendix in such a way as to completely conceal the lower half of the junction. Sometimes also the appendix or its mesentery is adherent in such a way as to conceal the line of junction. It may be concealed by bands formed between the cæcum, the appendix and the ileum, or by a fold of the ileum itself when bound by adhesions to the brim of the pelvis—Lane's kink. Before the repair of the valve can be undertaken, the junction must be brought clearly into view by the separation of adhesions. I think it important to note, however, that not infrequently these adhesions seem so clearly to be of a reparative character that it appears best to let them alone. Non-obstructive adhesions should be left undisturbed.

When the valve is competent, the line of junction between the ileum and the cecum cannot be seen, for the reason that it is located at the inner free border of the valve lips and so lies within the colon. It is only when the invaginated end of the ileum is pulled out, destroying the valve, that the anatomical junction of the ileum and the colon comes into view. When the junction line is visible, this fact alone proves incompetency.

A most striking anatomical feature of the incompetent valve is the form of the gut at its terminus, which is so characteristic that the lesion may be instantly recognized when the cæcum and terminal ileum are exposed to view (Fig. 3). Normally the small gut is narrowed at its junction with the cæcum. When the valve is incompetent, the wide stretching of the junction gives the terminus of the ileum a funnel shape (compare Figs. 1, 2 and 3). This is the natural result of the pulling out of the invaginated end of the gut and the overstretching of the cæcum to which the incompetency is due. The lumen of the normal ileocæcal junction measures two to two and one-half centimetres; when incompetent, four to seven centimetres.

After the gut has been brought into view and examined, the valve may be tested, compressing the gas-distended cæcum in such a way as to force the gas back into the small gut unless checked by the ileocæcal valve. It may be necessary to compress the ascending colon so as to confine the gas in the cæcum while making the test.

In testing the competency of the valve, it is sometimes at first found



FIG. 1.—Normal cæcum and terminal ileum.

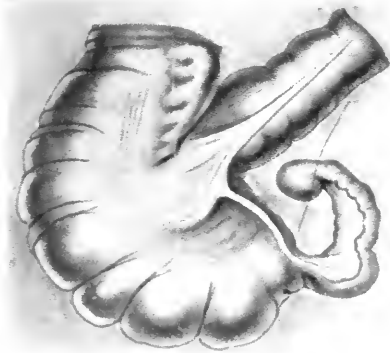


FIG. 2 —Cæcum and terminal ileum of the chimpanzee.

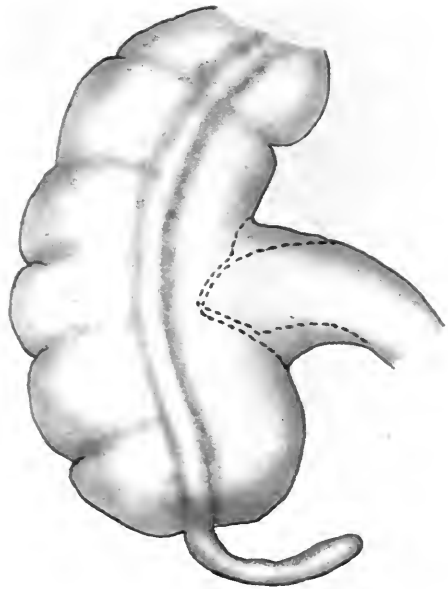


FIG. 3.—Incompetent ileocaecal valve. The dotted lines show the form of the normal junction and valve.

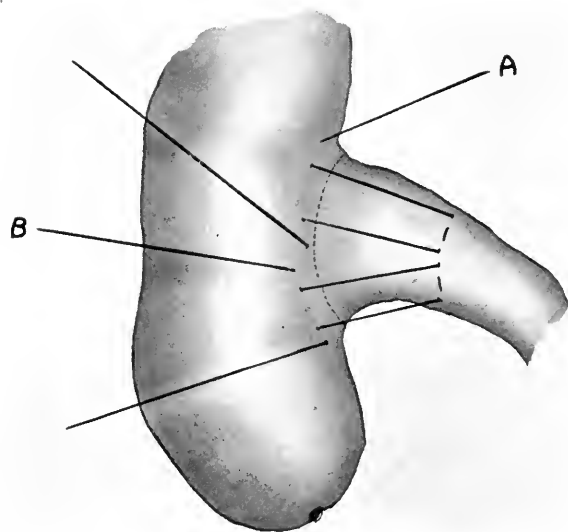


FIG. 4.—*A*, first anterior suture; *B*, second anterior suture.

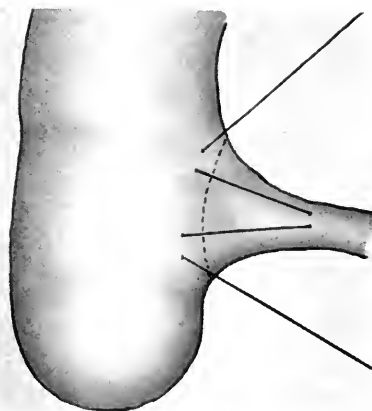


FIG. 5.—V-shaped suture.



impossible to cause reflux of gas into the ileum by pressure upon the cecum in cases in which the appearance of the ileocolic junction clearly indicates a marked degree of incompetency. In such cases, a slight change in the position of the ileum in relation to the colon will at once reveal the incompetency of the valve by permitting the gas to pass freely from the colon into the ileum. This temporary competency of the valve may be due to an accidental disposition of the folds of mucous membrane about the ileocolic junction in such a way as to mask the incompetency. If the ileum is placed at right angles to the colon, or if gas is pressed into the colon from the ileum, the true condition of the valve is at once disclosed by the sudden refilling of the terminal ileum with gas, often with a slight puffing sound when pressure is made upon the cæcum.

In nearly every case of incompetency of the valve the upper or superior valve is found to be deficient, while the lower valve is not infrequently found to be intact as shown by the fact that the ileum is not disinvaginated at this point. For this reason I usually begin the operation by restoring the upper valve.

The operation consists in the application of one or more mattress sutures in such a way as to turn in three to three and a half centimetres of the ileum and at the same time reduce the lumen of the opening.

In passing the first suture, the needle should be inserted into the wall of the colon at a point half a centimeter from the line of junction and opposite the mesenteric border of the ileum (Fig. 4-A). This point cannot be seen without first lifting and pushing aside the peritoneum with its veins and fat which cover this part of the junction. To avoid troublesome bleeding and the application of ligatures the dissection must be made with the very greatest care. The loose peritoneum close to the junction is picked up with dissecting forceps, thus separating it from the underlying muscular coat. With a pair of small forceps, the pouch of loose peritoneum thus formed is penetrated and an opening made by separating the blades of the forceps. When this is carefully done there is no bleeding, and by pushing the veins and fat aside the surface of the colon may be readily distinguished by its lighter color. The forceps are pushed under the veins and made to seize the colon at a point at which it is desired to insert the needle in placing the first suture. Of course special care must be taken in inserting the needle to avoid perforating either the veins or the gut. A small curved needle, as a Lane's cleft-palate needle, is best for the purpose. No. 0 silk or celluloid linen is used for the suture.

Before the several sutures are placed, the peritoneal surfaces which will lie together when the sutures are tied are abraded by means of scraping with a sharp scalpel so as to insure prompt and permanent adhesion of the invaginated folds.

The needle is next inserted at a point in the ileum close to its mesenteric border and about three centimetres from the junction. The next insertion of the needle is at a point about one centimetre and a half from the

mesenteric border and three centimetres from the junction line. The needle finally picks up the colon at a point in line with the first insertion and two to two and a half centimetres anterior to it, thus forming what might be called a double mattress suture. The suture is left untied, the ends being grasped by forceps.

Generally a second mattress suture, essentially like the first, is applied anterior to it (Fig. 4-B) and in many cases a third is required on the under side.

Sometimes it is best to give the suture the form of an inverted V (  $\Lambda$  ), the base of the V resting upon the colon (Fig. 5).

All the sutures are introduced before any are tied. In tying, a pair of forceps is passed under the suture and held by the assistant in such a way as to make sure that the gut is well invaginated. The knot is left half tied until the valve has been tested.

It is well, after introducing the first suture and thus reproducing the superior valve lip, to test the competency of the valve by first filling the cæcum with gas from the small intestine, then making pressure upon the cæcum in such a way as to force the gas back against the valve and through it in case it is incompetent. If the valve is competent it will bear a considerable amount of pressure without permitting gas to pass into the ileum. If moderate pressure causes a reflux of gas into the intestine with a puff or a low-pitched sound, the repair is not sufficient and further repair is required.

The inferior lip of the valve is now restored by means of a mattress suture applied as described for the anterior, after which the valve is again tested. If the valve is still incompetent, it is necessary to apply a single or a V-shaped invaginating suture at the anterior border of the junction just anterior to the fold of Treves.

After placing the sutures and half tying them, and having proved that the valve is competent, it is highly necessary to make sure that the operation has not been overdone. For this purpose it is only necessary to pass gas from the ileum into the colon by holding and compressing it with a moist napkin at a point eight or ten inches from the cæcum, then passing the gas into the colon by grasping the gut between two fingers and stripping it toward the valve. If resistance is felt, one or more of the sutures must be loosened a little, or possibly removed and the test repeated.

If after repairing the valve moderate pressure upon the distended colon causes a reflux of gas into the ileum accompanied by a high-pitched sound, the inference to be drawn is that the terminal ileum has not been invaginated sufficiently, and also that the sutures produce too much constriction. One or more sutures must be cut and removed and the error corrected.

That the danger of overdoing the operation on the ileocæcal valve may be avoided by a painstaking technic is shown by the fact that a serious obstruction of the intestine due to the operation on the valve has, in the writer's experience, occurred in only a single instance. In not a single case has death resulted from obstruction of the valve.

Care should be taken to avoid much manipulation of the intestines and all exposed parts should be kept well moistened with normal saline solution.

After the operation the patient is cared for by the method of post-operative care which the writer has followed in laparotomy cases for many years. As soon as the patient is transferred to his bed a hot pack is applied to the feet and legs, to lessen pain, a cool friction bath is given and a cold compress is applied to the chest to combat shock. The patient's body is inclined to the left side to lessen strain on the cardiac end of the stomach and thus lessen nausea as suggested by Lauder Brunton. The patient is given a glassful of water every hour by mouth and every two hours a half pint of water containing an ounce of malt sugar is given per rectum to combat acidosis. Heat is applied to the abdomen over the dressings. The hot application is repeated several times a day for several days to combat adhesions and lessen pain. After the first day the patient is made to take several deep breaths every hour to empty the splanchnic vessels.

To insure complete emptying of the intestine, and to lessen the discomfort of the patient by getting rid of the gas which in these cases nearly always fills the small intestine and distends the colon, a dose of one ccm. of pituitrin extract is given immediately after the operation, and soon after the patient is transferred to his bed a hot enema (two or three pints) is administered. The addition to the enema of a half pint of molasses or, better, of malt extract, renders it much more effective. Sulphate of magnesium or glycerine (one ounce to the enema) may be used instead of molasses with good results. The patient is also given five grains of carmine in a capsule and an ounce of an emulsion of white paraffin oil. The appearance of oil floating upon the water returned after an enema and the carmine color afford certain evidence that material is passing through the valve.

When the patient suffers from an accumulation of gas, the enema is repeated until relief is obtained, the enema being allowed to return through the rectal tube. The efforts to move the bowels must be thorough and persistent but it must be remembered that the patient needs rest and sleep and must not be exhausted by over-attention.

A thorough evacuation of the intestine must be secured not later than the third day, and earlier is better.

The injection of pituitrin extract may be made daily for several days following the operation if necessary to insure complete bowel action.

*Post-operative Care.*—It is important to watch the urine with great care. The appearance of a large amount of indican is a very certain indication of ileac stasis. The amount of indican present should be estimated by the Folin method. Accumulation of gas in the small intestine is indicated by distention of the abdomen which is not relieved after evacuation of the colon by means of enemas.

The X-ray affords altogether the best method for determining the condition of the ileum. By means of the technic devised by Dr. James T.

Case, it is possible in every case to know the exact condition of the small intestine. When post-operative stasis exists, the intestine becomes distended with gas, and the gas-distended coils of the intestine are clearly shown by the X-rays, so that the surgeon need not remain in a state of uncertainty as to whether or not intestinal obstruction exists. The accuracy of this method is very great in skilled hands and its importance cannot be over-estimated. The writer requires as a routine practice in the hospital under his care the roentgenological examination on the second morning after operation in all cases in which the abdomen has been opened and vomiting is persistent and also when the bowels do not move satisfactorily. In doubtful cases, any uncertainty may be cleared up by giving bismuth or barium to facilitate the X-ray examination, and the examination should be repeated daily until the bowels move freely and all occasion for anxiety disappears. An X-ray examination by a competent röntgenologist is in these cases of the very greatest service and should be made a routine practice after laparotomy when nausea or vomiting persist or the bowels fail to move freely.

It is important to get the bowels moving normally as soon as possible. The ordinary plan of fasting or liquid diet is highly conducive to constipation. The use of anodynes to relieve pain operates in the same direction, as do also the rest in bed and the use of laxatives in preparation for the operation. Starvation leaves the bile, mucus and other secretions and wastes to accumulate and putrefy. Thin gruels and broths are little better than nothing. Laxatives cause a spastic condition of the descending and pelvic colon and greatly exaggerate the antiperistaltic movements which Cannon has shown have their origin in the transverse colon. This has been clearly demonstrated by Case.

To avoid these difficulties the patient is prepared for the operation by the free use of paraffin oil and bran or agar-agar. Enemas are given the night before and the morning of the day of operation.

After the operation, an enema is given at once and daily, and feeding with orange juice and other fruit juices and purées is begun at once, or as soon as nausea and vomiting cease when these are present. Food is the natural laxative. Fruit acids excite the gastric glands and so encourage the secretion of hydrochloric acid and also stimulate gastric and intestinal motility.

Malt sugar is also given freely, an ounce in half a pint of water every two hours when the patient is awake, or eight ounces daily. This combats acidosis, a condition to which persons long subject to intense intestinal toxæmia are especially liable.

On the third day porridge is added to the diet. This is made of a mixture of cereals, oatmeal, cornmeal and sterilized (cooked) bran. The porridge is made with eight parts of water to one of cereal and is cooked not longer than ten minutes. The patient receives four ounces of this porridge every four

hours in connection with fruit purées and fruit juices. An ounce of paraffin oil or paraffin emulsion is given four times a day.

From day to day the variety of the diet is increased by the addition of green vegetables and vegetable purées. Medicinal laxatives of any sort are very rarely needed.

The patient is made so comfortable by direct and derivative applications of heat and by deft nursing that anodyne drugs are seldom required.

*Post-operative Regimen.*—In order to secure the best results after operation for repair of the ileocæcal valve, the patient should permanently adopt a regimen which will produce a definite change of the intestinal flora. The measures necessary to accomplish this the writer has described in other papers.<sup>1</sup>

Since the publication of the first paper describing my operation for repair of the ileocæcal valve I have modified the original technic in several particulars. The results have improved as the following details have been more closely adhered to:

(1) Increase in the amount of invagination of the ileum, the optimum amount being three centimetres; (2) less constriction of the lumen of the gut at the point of junction; (3) avoiding any disturbance of adhesions about the terminal ileum when not clearly shown to be obstructive; (4) the administration of a dose of pituitrin extract (1 c.c.) directly after the operation and each day for two or three days until paraffin oil or carmine administered by mouth appears promptly and abundantly in the stools.

The advantages of the operation are fairly shown by the results obtained in a series of twenty-six cases operated between January 1 and December 31, 1915, and which were subject to a careful X-ray examination with reference to ileac stasis and the condition of the valve both before and after the operation.

Of the twenty-six cases in which before operation the valve was shown to be incompetent both by X-ray examination by Dr. Case and by testing the valve at the operating table after opening the abdomen, the valve was found competent after the operation in 23 cases or 88 per cent. In the one case in which the repair was not complete, the incompetency was accompanied by ileac stasis and there were marked adhesions about the terminal ileum and the pelvic colon. The latter were divided but the pelvic colon was not suspended. The operation memoranda show that only one invaginating suture was introduced (posterior) and that the ileum was turned in only two centimetres. The invaginated fold of gut should have been longer, a second suture should have been applied and the pelvic colon should have been suspended by the omentum.

As regards ileac stasis, the results were as follows: marked stasis existed before the operation in all but three (99248, 94728, 96384) cases as shown by the X-ray examination. In these three cases the clinical

<sup>1</sup> Incompetency of the Ileocæcal Valve, Medical Record, June 21, 1913. Should the Colon be Sacrificed or May It be Reformed? Jour. A. M. A., June 30, 1917.

evidence of ileac stasis was present, and as all had been under treatment for two to five weeks and had been given liberal doses of paraffin oil and agar-agar or other mechanical stimulants, it is a fair presumption that ileac stasis was present and was temporarily masked by treatment. Of these three cases ileac stasis was found present in one (96384) after the operation, notwithstanding the fact that the valve was competent. The memoranda of the operation show that two sutures were placed and the lumen of the junction lessened  $3\frac{1}{2}$  centimetres. It is probable that the constriction was slightly too great. Experience has convinced me that a very moderate degree of constriction is sufficient in case the small gut is infolded to the extent of 3 to  $3\frac{1}{2}$  centimetres. It is probable that the excessive constriction soon disappeared, for two months later the patient reported herself as feeling well and much improved by the operation.

In three cases (97329, 94992, 95110) there was stasis both before and after operation. In one of these the post-operative stasis was slight. The operation memoranda show that in two of these cases a Lane's kink existed. In one case (97329) the kink was evidently not obstructive and was not disturbed. A single suture with 2 centimetres infold was applied. The repair was insufficient. In another case (95110) the adhesions of the terminal ileum were divided. The usual effect of this as shown by Dr. J. T. Case is to render the gut spastic for some time after the operation. This was probably the cause of the stasis. In the third case (94992) the ileal stasis may be fairly attributed to a gastric stasis of eight hours which existed before the operation and persisted after. Careful examination of the stomach at the time of operation showed no mechanical cause for the stasis.

The total result of the operation in the 26 cases as regards ileac stasis was complete relief of stasis in 22 cases or 84.6 per cent. Omitting the case in which the post-operative stasis was due to slow emptying of the stomach, the better result of 88.4 per cent. is shown.

As regards clinical results, it certainly cannot be claimed for this operation that it is a panacea for all chronic ailments, but that it does restore the function of the incompetent ileocaecal valve and that it does thus cause the disappearance of ileac stasis is clearly shown by the post-operative X-ray findings made by Dr. J. T. Case by his usual careful technic. If no other evidence of benefit from the operation than this could be produced, its performance would be amply justified; but abundant clinical evidence of benefit is available. Of the 26 cases comprised in this series, all of whom were operated more than six months before the writing of this paper, 18 (69 per cent.) replied to a circular letter in which mention was made of the leading symptoms for relief of which the operation was done, and the patient was asked to indicate which symptoms, if any, had disappeared, which had diminished, and which were unchanged.

Each one of the eighteen cases which replied reported improvement

in one or more important particulars. In 9 cases (50 per cent.) practically all symptoms disappeared after the operation.

In view of the above evidence I think it fair to claim for the operation for repair of the ileocæcal valve the following advantages:

1. It removes the most common of all causes of ileac stasis by restoring the competency of the ileocæcal valve, and so relieves the stasis.
2. By curing ileac stasis it removes the cause of a large number of chronic morbid conditions which depend upon intestinal toxemia.
3. The simplicity of the operation and the fact that it is reparative and conservative in character, correcting an anatomical defect and restoring an important lost function, should recommend the operation in cases in which other structures are not so badly damaged by disease that more radical measures are indicated.

It must be constantly borne in mind that incompetency of the ileocæcal valve is an acquired defect and that it is secondary to a diseased condition of the distal half of the colon which contracts the lumen of the gut and leads to exaggerated antiperistalsis. In the four cases of the series in which ileac stasis was not completely relieved, adhesions of the pelvic colon existed in each case, and it is quite possible that the persistence of ileac stasis in these cases was in part at least due to a reproduction of the adhesions or to the spastic condition of the gut which commonly persists for some time after division of adhesions, or to an existing colitis which had not yet been completely cured.

It should be mentioned that in all the above cases lesions existed besides incompetency of the valve so that the operation was not done solely for the purpose of repair of the valve, although in quite a number of cases the symptoms properly attributable to incompetency of the valve were so pronounced that an operation expressly for repair of the valve might have been considered justifiable.

In concluding this paper the writer desires especially to emphasize three points.

1. Not every case of incompetency of the ileocæcal valve requires operation. In the writer's experience at least nineteen out of twenty cases may be relieved of all serious symptoms by a regimen which will combat intestinal putrefaction and secure two or three bowel movements daily, although of course the valve remains incompetent. Paraffin oil with agar-agar or sterilized wheat bran is highly useful and wonderfully efficient in these cases.

2. It is very rare indeed that the operation will be indicated without the presence of other conditions which in themselves constitute definite indications for operation, such as chronic appendicitis or adhesions of the pelvic colon or some other obstructive lesion.

3. Incompetency of the ileocæcal valve is always a result of some obstructive lesion of the colon. This lesion may be organic,—adhesions, tuberculosis, cancer; or functional—spastic contraction of the distal portion

of the colon, usually associated with colitis. No permanent benefit can be expected from any operation upon the ileocaecal valve unless the primary lesion of which it is a result is also successfully dealt with. Colitis must be cured by changing the intestinal flora. Any other cause of spastic contraction of the gut must be removed. The prolapsed and adherent pelvic colon must be released and suspended by the omentum so as to prevent recurrence of the obstructing adhesions. Neoplasms and other organic lesions must be dealt with when present, by appropriate procedures.

It must be remembered that practically the sole indication for the operation of repair of the ileocaecal valve is the relief of ileac stasis, by which is meant a delay of the bismuth or barium meal in the small intestine amounting to more than nine or ten hours after the ingestion of the meal. The more prolonged the stasis and the more serious the disorders arising from it, the more positive the indication for operation, provided of course, that other rational measures such as a bulky vegetable diet and the use of paraffin oil do not relieve the stasis and cause to disappear the secondary symptoms of stasis, such as headache, loss of appetite, foul breath, indicanuria, etc. Fortunately these non-surgical measures succeed in by far the great majority of cases. I desire to emphasize this point because I do not wish to be understood as maintaining that every person who is shown by X-ray examination to possess an incompetent ileocaecal valve should be advised to submit to an operation for repair of the valve. As a matter of fact all but a very small proportion of these cases may be made perfectly comfortable by an antitoxic and laxative diet. By cutting down the protein to the minimum requirement for tissue building, a quantity not exceeding ten per cent. of the total ration, estimated in calories, and by increasing the activity of the intestine to three or four efficient bowel movements a day so as to effect such complete and rapid clearance of the intestine from putrefiable food residues as to leave no opportunity for putrefactive changes, the evils resulting from incompetency of the ileocaecal valve may be made to rapidly disappear in by far the great majority of cases. The incorrigible cases are those in which obstructive lesions are present which so interfere with the normal action of the gut as to cause greatly exaggerated antiperistalsis and distention of the caecum and proximal colon with decomposition of food residues and body wastes.

The number of cases which have been definitely cured of ileac stasis by repair of the ileocaecal valve and removal of mechanical hinderances in the distal colon is now so considerable that I feel justified in making the claim that the lesions mentioned are the true cause of ileac stasis rather than Lane's kink, and in maintaining that when surgical interference becomes necessary the procedure indicated is the simple one of repair of the valve rather than the serious and mutilating operation of short-circuiting or of colectomy, except in cases in which the existence of neoplasms or other lesions positively obstructive in their nature can be clearly proven.

Dr. Case, who has studied röntgenologically all the cases in which I have



## REPAIR OF THE ILEOCÆCAL VALVE

repaired the ileocæcal valve, reports in an interesting paper the results of his observations as follows:

"I have already reported post-operative studies on more than one hundred cases in which this operation for restoration of the ileocæcal valve competency has been performed. With only three or four exceptions, the Röntgen-ray diagnosis of ileocolic valve incompetency was confirmed at operation, and the valve competency was restored by the simple operation above mentioned. That the competency was restored was proved, not only by testing the valve *in situ* before the abdomen was closed, but later by röntgenologic tests. Although, in several instances, more than a year and a half had elapsed since the operation was performed, in only three or four cases out of the hundred did subsequent röntgenoscopy find the valve incompetent.

"The effect of the operation on the emptying-time of the ileum has also been tested by the bismuth meal, but thus far no evidence has been secured which would lead me to believe that the operation has caused the slightest interference with the passage of ingested food from the ileum into the colon. On the contrary, the emptying-time of the ileum, which before the operation was in every single instance prolonged, has been definitely shortened, nearly always within eight hours."<sup>1</sup>

In the same paper Dr. Case thus comprehensively summarizes the evidence of the essential importance of the ileocæcal valve anatomically and functionally:

"1. The ileocæcal valve is almost universally present in vertebrate animals; and, at least, in the dog, pig, and cat, the valve is competent to the enema, withstanding enormous distention of the colon by fluid and gas.

"2. By means of a string passed through the alimentary canal traction may be made on the valve lips, producing temporary incompetency.

"3. In about one-sixth of three thousand persons, most of them constipated and all suffering from gastro-intestinal disturbances, the bismuth enema passed the ileocæcal valve and filled the terminal ileum for varying distances.

"4. The valve incompetency thus determined is a constant phenomenon in these cases.

"5. Patients with incompetency of the ileocæcal valve describe characteristic disagreeable symptoms apparently due to passage of the enema into the small intestine.

"6. In the marked cases there is also observed a reflux of ingested bismuth from the colon back into the ileum.

"7. The occurrence of the incompetency is, to a large degree at least, independent of the temperature or composition of the opaque enema.

"8. The incompetent ileocolic valve may be restored to competency by a simple surgical procedure.

"9. In operation on patients with incompetent ileocolic valve the small bowel is found filled with gas to a very disturbing degree.

"10. It is possible in the operation of ileosigmoidostomy to construct an efficient artificial ileocolic valve which will successfully act as a barrier against reflux from the colon.

"11. Definite deviations from the normal anatomic structure are found at operation on cases of ileocæcal valve incompetency.

"12. Post-mortem studies show the ileocolic valve to be competent in the great majority of cases."

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<sup>1</sup> Journal A. M. A., October 3, 1914.

## DUMB-BELL STONE IN DIVERTICULUM OF URINARY BLADDER

BY SERGEANT PRICE MARTIN, M.D.

OF BUFFALO, NEW YORK

THE patient, a male, aged forty years, whose family history and previous medical history were negative, presented himself at the Mayo Clinic on April 19, 1916 (Case 157750 (J. H.)), complaining of difficulty in urination. He stated that he had been perfectly well in every way until seven years previously, when immediately after doing some heavy lifting, he became nauseated and for twenty-four hours was unable to urinate. At the end of that time he had to be catheterized, his doctor drawing off a large clot of blood before the flow of urine began. After this he remained well for six months, save that his stream would often shut off suddenly in the middle of urination. At the end of this time urine again stopped entirely, necessitating catheterization. Since then (a period of six and one-half years) he has been bothered nearly every time he urinated by his stream shutting off suddenly before he was through voiding. His bladder has never felt completely empty and for the past year he has been using a catheter once a week. He has had no frequency of urination and has never passed any blood, pus or gravel in his urine. He has never had any chills or fever. His general condition has been good in every way.

Physical examination showed a pale, well-nourished adult male; height five feet and six inches; weight 142 pounds, with all physical findings normal, save for a firm mass in the right posterior wall of the bladder, which could be easily palpated per rectum above the prostate.

Analysis of twelve-hour specimen of urine showed: amount, 450 c.c.; specific gravity, 1020; acid reaction; some albumin; no sugar; an occasional red blood-cell; pus in abundance.

An X-ray of the kidneys, ureters and urinary bladder (Fig. 1) showed a dumb-bell-shaped shadow in the right side of the bladder. The larger end of the shadow appeared about the size of a hen's egg, the smaller about the size of a robin's egg. They were connected by a narrow middle piece which appeared about the size of an ordinary lead pencil in diameter.

Cystoscopic examination showed a stone about the size of a robin's egg fixed to the right posterior wall of the bladder and apparently protruding from a diverticulum.

*Operation* (May 5, 1916).—An incision was made extending from the symphysis pubis to just below the umbilicus. The tissues and muscles were separated down to the bladder. The peritoneal covering of the bladder was then stripped back. A diverticulum two inches in diameter was exposed on the right posterior wall of the bladder, which was completely filled by the large portion of the stone,



FIG. 1.—Skiagraph of calculus in diverticulum of the urinary bladder.

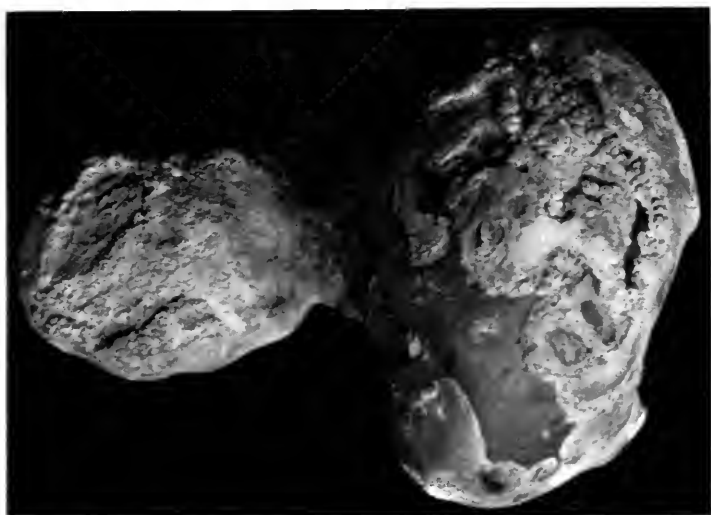


FIG. 2.—The calculus after removal.



## DUMB-BELL STONE IN DIVERTICULUM OF BLADDER

which was 5 cm. long by 3 cm. in diameter. The diverticulum was opened and the stone was removed through this opening. Following this the sac of the diverticulum was excised and its opening into the bladder was closed by a series of interrupted sutures of chromic catgut, so taken as to invert the mucous membrane toward the bladder cavity. These were further strengthened by a continuous suture of chromic catgut. The recti muscles were brought together with interrupted sutures of Number 2 plain catgut. Fascia and skin were brought together by a figure-of-eight silkworm-gut, and the skin edges were held together by a continuous horse-hair suture. No drains were inserted. The small portion of the stone was 3 cm. long, with a diameter of 2 cm. The two portions were united by a narrow middle piece, which was  $1\frac{1}{2}$  cm. in diameter (see Fig. 2).

A second cystoscopic examination made five weeks after the operation showed a normal bladder in every respect save for a slight scar on the right wall where the opening of the diverticulum had been.

A review of the literature of the past ten years on diverticula of the bladder discloses only few references to instances in which stones have been found in diverticulum. Thomas, in a recent complete study of all cases of diverticula examined in the Mayo Clinic during the past eight years, reported twenty-seven cases. In only three were stones found. Two of these each contained a single stone, while the third contained several small stones, but none were dumb-bell in shape nor of such great size.

NOTE.—The observations on this case were made by the writer while he was an assistant in the Urological Department of the Mayo Clinic. He wishes to thank Dr. W. F. Braasch, Head of the Section on Urology, for his courtesy in permitting the use of the material.

## NOTES ON THE RECOGNITION OF CERTAIN LESIONS OF THE MALE BLADDER

BY ERNEST M. WATSON, M.D.

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FROM the introduction of the cystoscope by Nitze in 1876 and three years later perfected by the incandescent light bulb of Edison, the study of bladder lesions has been one rapid advance of diagnostic and therapeutic achievement. At first it was the grosser abnormalities and the technical manipulation of instruments that occupied the attention of workers in this field, but in recent years with the newer and more delicately constructed types of cystoscopes more attention has been given to detailed vesical study both for purposes of diagnosis and for treatment.

To-day the cystoscope with its various modifications is indispensable in the study and diagnosis of practically all urinary disorders. The success in the treatment of these conditions almost invariably depends upon the ability of the observer to interpret correctly the cystoscopic findings. In this brief consideration the following intravesical lesions will be discussed:

I. Prostatic changes: (a) Hypertrophy (benign): (1) Middle and lateral lobe involvement; (2) Albarran lobe involvement; (3) subtrigonal gland involvement. (b) No hypertrophy: (1) Median bar formation; (2) median bar with circular fibrosis. (c) Cysts of the prostate.

II. Trigonal hypertrophy.

III. Bladder changes due to spinal lesions.

IV. Vesical tumors: (a) Benign papilloma; (b) malignant growths.

V. Calculi: (a) Vesical calculi; (b) ureteral calculi (intramural).

VI. Vesical diverticula.

VII. Vesical tuberculosis.

VIII. Cystitis: (a) General cystitis; (b) localized cystitis.

In the study of a suspected prostatic after a careful clinical history and record of the urinary findings the palpation and digital examination of the prostate per rectum is the first step. This, however, gives one no detailed information as to the character of the intravesical prostatic enlargement, and this after all is most important. Through the cystoscope<sup>1</sup> the degree and exact type of glandular enlargement can be accurately determined. The more common type of intravesical hypertrophy is that which involves the middle and two lateral lobes singly or in various combinations. The anterior lobe is less frequently and, in fact, rarely hypertrophied. The middle lobe hypertrophy is determined by the oval or convex outline of the middle portion of the prostate when the lumen of the observation telescope is turned posteriorly, or looking backward toward the rectum. This

curved or rounded margin, which should be followed around on either side toward the lateral aspects of the vesical orifice, to observe whether the enlargement is merely a rounded elevation distinctly raised above the trigone, or a definite lobe formation, with clefts between it and the lateral lobes, is diagnostic of middle lobe hypertrophy. In a similar way the cystoscope should be turned or rotated to bring into view successive segments of the prostatic orifice, observing the lateral aspects to determine in a like manner their contour or oval outline, for the enlargement of the lateral lobes is similarly determined. The normal prostatic outline in each segment shows instead of a convex border a slightly concave margin, except in the middle portion, where it is nearly straight or perhaps very slightly convex but with no appreciable elevation above the trigone. In addition to the marginal contour of the prostatic orifice as viewed with the cystoscope drawn well out so that the inner lens is just within the internal sphincter, the presence or absence of clefts or sulci between the lobes should be noted. The usual location of the clefts in a triple lobe hypertrophy is anteriorly (looking up toward the symphysis) where the two lateral lobes when hypertrophied join above, and posteriorly on either side of the median where the lateral lobes impinge on the middle lobe on the right and left sides. Not infrequently one or both lateral lobes join the median without any appreciable sulci, giving instead a continuous projecting mass of convex contour about the lateral and posterior aspects forming the so-called "collar type" of hypertrophy.

In hypertrophy of the Albarran group of glands<sup>2</sup> located in the submucous structures just below and within the internal sphincter posteriorly and at the apex of the trigone, the enlargement is noted as an elevation varying from a small thickening to a definite rounded protuberance similar to a middle lobe but situated a little farther within the bladder.

Still higher up occurs the group of glands known as the subtrigonal mass at about the middle of the trigonum vesicæ. This group by their important position, when involved in the hypertrophy, may cause as many if not more urinary symptoms than in the true prostatic hypertrophy. Upon the recognition of these different anatomical types of obstruction due to true hypertrophy of the tubular elements about the vesical orifice depends very largely the success of their operative removal. In their surgical treatment lies the only source of relief. This may be accomplished either suprapubically or by the perineal route. In the light of the lower mortality, greater comfort of the patient and shorter period in bed, the perineal method seems more to be desired unless there are definite contra-indications to it.

In addition to the hypertrophied types of obstructing prostates there is another group which is equally as troublesome symptomatically and particularly interesting and important from the standpoint of diagnosis and treatment. These are the so-called obstructing prostates with no hypertrophy, or "Prostatisme sans Prostate" as termed by Randall,<sup>3</sup> who has recently given us a very comprehensive study of their history, diagnosis and

clinical importance. This group first described and studied by Guthrie<sup>4</sup> and later by practically all the men whose names stand out among the makers of Urology during the past hundred years have come now to be known as the "median bar" type of obstruction. In these cases it is by cystoscopy alone that the diagnosis has to be made. Here the median portion of the prostate is seen through the observation cystoscope distinctly raised above the level of the trigone, and the outline is a very definite convex border, notably more rounded than normal, and as the margin is traced to either side it is found to fade away into a normal lateral contour in the right and left segments without any cleft formation. This shows no hypertrophy of the lateral lobes and by a trigonal study it is seen that the apex of the trigone is slightly, but nevertheless definitely, obscured by the elevation. For additional evidence an examination of the recto-urethral thickness should be made. This is done with a finger in the rectum and the cystoscope in the urethra, the beak turned posteriorly, when an accurate idea of the degree of thickness of the median portion of the prostate can be obtained by palpation between the finger and the shaft of the instrument.

Not infrequently instead of merely a median bar there is a definite thickening about all the segments of the orifice, similar to a sclerosis or the "*Contracteur du col de la Vessie*" of the French writers,<sup>5</sup> yet not akin to a real "collar type" of hypertrophy which is a glandular enlargement but without any definite lobes or cleft formation. The diagnosis established in this class of obstructing prostates, the question of treatment is relatively simple. In the first place a prostatectomy is not necessary nor is it indicated. A procedure like Chetwood's galvano-cautery knife, Geraghty's knife for slitting the vesical orifice, fulguration as advised and practised by Randall, or Young's punch operation<sup>6</sup> is of the type that bring the best results. Of these the punch operation of Young is perhaps the best, inasmuch as it is performed under novocaine entirely through the urethra, requiring the patient to remain in bed only three days and allowing him to leave the hospital in less than a week. The results in the cases for which it is adapted are excellent and there is practically no mortality.

Prostatic cysts play a very definite and important rôle in obstructions about the vesical orifice and in relatively young men, *i.e.*, under fifty years of age; with symptoms suggesting a true hypertrophy, but practically no hypertrophy per rectum, they have to be considered. Cysts to have a clinical importance have to be large enough to project into the vesical cavity and to be located fairly near the vesical mucosa. Cystoscopically they may simulate enlarged prostatic lobes and frequently when more than one is present typical clefts between them can be noted. They can be diagnosed by their translucency, mobility, and compressibility by the end of the cystoscope and if doubt still exists by aspirating their contents. In most cases they can be removed endo-vesically by means of fulguration, by excision with the wire snare or scissors or by the rongeur cystoscope of Young<sup>7</sup> and only very rarely is a prostatectomy necessary.



II. *True hypertrophy of the trigone*, not the type of enlargement mentioned above due to changes in the subtrigonal group of glands, but rather a muscular hypertrophy, is a condition which occasionally occurs and when it does is deserving of considerable attention. This form of hypertrophy is usually secondary to some type of obstruction situated directly at the vesical orifice, *i.e.*, a general prostatic hypertrophy, a single middle lobe hypertrophy or a median bar formation. It appears to be the result of increased bladder activity in attempting to force urine through the obstructed orifice. Cystoscopically the trigone is seen considerably raised and generally hypertrophied and the inter-ureteric ligament particularly is in the form of a large ridge, back of which is a "bas fond" which may contain several hundred cubic centimetres of residual urine. In these cases which are found not rarely in relatively young men their urinary symptoms persist even after prostatectomy. The division of the inter-ureteric ligament and part of the trigone suprapubically and in some cases the excision of a wedge-shaped piece of the ligament is the only course that will give these individuals any benefit in addition to the removal of the obstruction at the orifice.

III. Another group of bladder lesions that is deserving of considerable study, particularly in the matter of differentiation from hypertrophic obstructive conditions, is the "*spinal bladders*."<sup>8</sup> These, from the standpoint of the urologist, come to mean the bladders of early tabes and cerebro-spinal lues. Here we find that the bladder capacity is unusually large and the tonicity is poor as evidenced by its power to expel fluid through a catheter. Cystoscopically the bladder wall shows considerable trabeculation, usually a great deal, situated over the lateral and posterior walls in no characteristic arrangement. The trigone is rather small and definitely atrophic. The inter-ureteric ligament is also small and flat without much distinction between it and the bladder mucosa adjacent to it. The ureteral orifices are usually large, sometimes dilated, and often fail to contract on functioning. Perhaps most important of all, however, from a diagnostic standpoint is the condition of the internal sphincter, which is often found dilated. This is determined by the ability to withdraw the cystoscope out past the sphincter into the prostatic urethra and view clearly the verumontanum. As corroborative evidence cystograms and careful studies of the reflexes, the blood serum and the spinal fluid are important.<sup>9</sup> In these patients when the findings are positive intraspinal therapy is indicated together with dilatations with the Kollman dilator and irrigations locally.

IV. The study of *bladder tumors* is a most interesting and important one cystoscopically. Clinically and practically the main issue is to determine whether the tumor is benign or malignant. The small pedunculated papilloma with the characteristic strawberry-like surface and particularly those with the fine filmy villi are usually benign. But when we find that the base or pedicle is wide and there is thickening of the adjacent bladder wall microscopic examination usually reveals a carcinomatous change. In addition most of the larger tumors have become carcinoma and have to be treated

accordingly. Whenever possible it is advisable to obtain a section for diagnosis, which can be done easily by means of the rongeur cystoscope. The benign papillomata respond best to fulguration, and even in the tumors of a questionable nature this is to be advised. Larger tumors, which fail to respond to fulguration, when so situated call for a resection. Other means at hand are radium combined with fulguration or resection to be used in suitable cases. In the frank cancer of the bladder most surgical means are of little value except as a palliative procedure. A total cystectomy, some years ago advised for otherwise inoperable cancer, has hardly stood the test of time as an advisable procedure in many instances.

V. *Vesical calculi* are readily and quickly diagnosed cystoscopically by their characteristic brownish or white color, by their mobility in the bladder and by their hard consistency when touched with the end of the cystoscope. Calculi in the intramural portion of the ureter should also be considered among vesical lesions.<sup>10</sup> They oftentimes are diagnosed by the bulging or ballooning of the ureteral opening on the affected side, and also by the scratches on the wax-tipped catheter passed just within the ureteral orifice. X-rays and pyelogram studies should also be made in these cases, however, for confirmatory evidence. Vesical calculi of any considerable size demand a suprapubic cystotomy for their best removal. Smaller calculi are readily treated by litholapaxy and some even are readily removed by the rongeur cystoscope. Calculi in the intramural portion of the ureter can most always be removed without a major operation. The dilatation of the ureteral orifice with bougies, its fulguration to enlarge its lumen, the employment of the ureteral probang of Geraghty<sup>11</sup> or the injection of olive oil or papaverin are usually efficient means in causing the calculus to pass spontaneously.

VI. The presence of *diverticula* is usually noted cystoscopically before they are demonstrated by other means. They appear as dark or almost black cavities arising from the bladder wall itself and are often situated just outside the ureteral orifices on either side or in the vertex of the bladder. They may, however, arise from other sites, but rather infrequently. They vary greatly in size, from that of a small marble to a cavity larger than the bladder itself. Often it is possible to introduce the beak of the cystoscope into the cavity of the diverticulum and observe its contour, size and determine the presence or absence of calculi within it. Small diverticula in the absence of symptoms, particularly in old men, are better left alone. Larger diverticula, when found in young men who are good surgical risks, demand operative treatment, particularly if there is a bladder infection with any considerable amount of residual or if there are any calculi present. The removal of the diverticula is readily accomplished suprapubically by everting the sac of the diverticulum by suction into the bladder cavity followed by excision.

VII. *Primary tuberculosis of the bladder* may certainly be said to be extremely rare; some writers hold that there is never a primary tuberculous cystitis. When we find a small contracted bladder that is highly sensitive

## LESIONS OF THE MALE BLADDER

and irritable, sometimes holding no more than 40-50 c.c. of urine, with a marked cystitis, tuberculosis is to be suspected. The bladder wall is usually markedly hyperæmic. This may be general or localized about one-half of the bladder or simply about one ureteral orifice. Often one ureteral orifice is entirely obscured in the inflammatory reaction. Ulceration may or may not be present, usually not in the early cases, but is almost universal in the older ones. Occasionally entire trabeculations are undermined and are observed suspended from either end across the bladder. In all cases where tuberculosis is suspected a careful study of the urine should be made for the acid-fast organisms. They are usually present and their demonstration is a matter of persistence in searching for them. All cases of tuberculous cystitis should be treated by eliminating the urogenital focus which is usually a kidney, an epididymis or the seminal vesicles. These possibilities must be ruled out before intelligent treatment can be instituted. Often the removal of the tuberculous focus causes a decided alleviation in the vesical symptoms, so that by antiseptic irrigations, internal medication, vaccine and by hydraulic vesical distention a relative cure can be hoped for, for a considerable period of time.

VIII. Accompanying practically all of the lesions mentioned above, particularly if they have existed for any length of time, there is usually a certain amount of *cystitis*. This also occurs from causes other than those mentioned above and on the whole is a very common lesion. It is noted by a hyperæmia of the bladder mucosa, and in the prominence and congestion of the blood-vessels. At times the inflammation may be of a catarrhal nature and flakes or clouds of mucus may be seen adherent to the bladder wall in almost diphtheritic form. Owing to the deposition of various urinary salts we encounter at times an encrusted cystitis, usually in strongly alkaline urines in which the various urinary crystals have become adherent to the inflamed mucosa. Occasionally we have the process after it has gone on to the breaking down of the mucosa, giving a real ulcerative cystitis (non-tubercular).

Another type of vesical inflammation called to our attention recently by Geraghty<sup>12</sup> is a localized resistant cystitis in distinction to those mentioned above which are usually generalized. This occurs mostly on the posterior wall and vertex of the bladder, seen best by a direct vision cystoscope, and frequently a mere star-shaped area of hyperæmia, but occasionally existing as a definite ulcer with an elevated puckered mucous membrane with broken edges. Most generalized cystitis (non-tubercular) is treated most satisfactorily by irrigations with the various silver preparations, usually the nitrate in various strengths and occasionally with argyrol or other newer synthetic compounds. In the localized forms the application of a strong nitrate solution direct to the affected area through a ureteral catheter under cystoscopic observation is employed with benefit. In the older resistant areas which still remain after all efforts to heal them an excision of the ulcerated patch is sometimes not only advisable but necessary to bring about a lasting cure.

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## THE TREATMENT OF GONORRHOEAL EPIDIDYMITIS, COMPLICATED BY PERI-EPIDIDYMITIS

BY CHAS. S. VIVIAN, M.D.

OF HUMBOLDT, ARIZONA

WHILE conservative non-surgical methods of treating gonorrhœal epididymitis still have their advocates, the rationale of surgical intervention is widely recognized.

Pirogoff is credited with having done the first epididymotomy in 1852. Later H. Smith adopted the same procedure in 1864, puncturing the inflamed epididymis from the outside. Operative treatment then fell into disuse until revived in 1906 by Francis P. Hagner. The technic advocated by Hagner is that which, with minor changes, has been employed subsequently. Fundamentally all operative procedures thus far outlined, from the simplest needle puncture of the epididymis with aspiration of the infected foci, to drainage of cavities reached by puncture with a blunt probe, or sharp instrument, following incision of the skin and tunica, owe their success to the same principle. The difference in methods is one of degree, and each has been tried in selected cases. During the course of a gonorrhœa when the epididymitis develops the meatal discharge slackens very markedly or stops altogether. In cases treated expectantly, when the epididymitis begins to subside the meatal discharge returns in progressive volume in direct proportion as the swelling of the epididymis diminishes. This is true also in cases treated surgically. We may then easily conclude that during the height of the epididymitis some factor prevents discharge from the epididymis through the urethra. What is more apt to produce this than infiltrative, purulent, or scar pressure upon the tube in the epididymis? In further support of this belief, surgical intervention frequently fails to evacuate pus, and only a little serum exudes on the dressings, but the condition improves immediately, pain is rarely present after operation, and the temperature reaches normal, to remain so, in less than forty-eight hours. Coincident with this improvement, as has been pointed out above, the meatal discharge returns. Can we not then safely conclude that the pressure of the swelling which causes intense pain also prevents discharge?

The author believes that if after epididymotomy the temperature falls to normal within forty-eight hours and remains there, the method employed is adequate. Conversely, other factors being excluded, if the temperature does not reach normal within this period, sufficient relief of pressure has not been secured. Acting upon this belief, more radical measures were adopted in certain cases. The procedure used is, to the author's knowledge, not specifically described elsewhere in the literature in this connection,

although it is included in, or is incidental to, the technic of radical cure of hydrocele. Obstinate cases treated expectantly for a period of several weeks develop inflammatory adhesions between the testicle and epididymis on one hand and the enveloping tunica on the other. Very virulent acute cases if not immediately relieved produce similar pathology. These two classes of cases are the ones which relapse repeatedly or drag on indefinitely under medical management. The following technic was developed or borrowed to cope with the situation. Under ether or gas anæsthesia the scrotum of the affected side is opened by a long incision, as in the Bergman operation for hydrocele. The tunica, which is usually hardly recognizable because of its reddened, thickened, and friable character, is separated by sharp dissection from the underlying structures. It will be torn in places, and these sections should be removed. Both testicle and epididymis should be laid bare, bleeding points controlled by pressure or ligature, and if sufficient healthy tunica remains it may be sutured behind the testicle, as in the bottle operation. Any of the tunica which is of questionable soundness is better excised. The epididymis is now punctured by a blunt probe, which is made to enter all possible pockets, a few twisted silk-worm-gut sutures are inserted for drainage to be removed in forty-eight hours, and the scrotum is closed down to the drain. The cases treated in this manner by the author have left the hospital cured within ten days of operation, which in every case relieved the pain immediately and caused the temperature to reach normal within thirty-six hours.

Incidentally, hydrocele, which is frequently a bothersome and recurring complication, is adequately dealt with.

#### CONCLUSIONS

Epididymitis of long standing develops what might be called peri-epididymitis, which is best treated by the radical method described.

The epididymis has an opportunity to return to more nearly its normal size.

This method has the advantages of the other surgical measures without danger of relapse.

It provides the most free drainage possible.

Fulminating acute cases and cases which have been unsuccessfully treated in other ways are best suited for this procedure.

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# TRANSACTIONS

OF THE

## NEW YORK SURGICAL SOCIETY

*Stated Meeting, Held October 24, 1917*

The President, WILLIAM A. DOWNES, M.D., in the chair

### ULCER OF THE STOMACH WITH CARCINOMATOUS DEGENERATION

DR. FRANZ TOREK presented a woman, thirty-seven years of age, who had been ill for nine months, giving a history such as has been considered typical of duodenal ulcer—epigastric pain beginning three or four hours after meals and relieved by eating. The stomach contents showed the presence of 20 per cent. free acid and 36 per cent. total acid. The röntgenogram showed a defect in the region of the pylorus. On operation, an indurated area was found in the pyloric portion of the stomach, close to the pylorus, which appeared suggestive of a new growth and was therefore excised. The specimen, which is presented, consists in the main of a crater-like perforating ulcer extending to, but not through, the serous coat. The carcinomatous infiltration extends for a considerable distance into the muscular layers but does not penetrate the peritoneal coats.

Doctor Torek presented, also, a man who had an almost identical history and clinical findings,—duration two and a quarter years, pain two hours after meals, relieved by eating, free acid 26 per cent., total acid 40 per cent. The röntgenogram showed an ulcer at the pylorus. On operation, as in the first case, an indurated area was found close to the pylorus. The specimen shows a very small area of new growth. The main interest in this case is that although the carcinomatous area is so very small, tumor embolism in the vessels is plainly apparent in the microscopical section.

DR. ROBERT T. MORRIS presented a fresh specimen of papillomatous growth of the stomach, macroscopically polyadenoma, which he considered very unusual. The patient was a man 64 years of age referred to him with a diagnosis of carcinoma of the stomach. Laboratory findings showed an absence of free hydrochloric acid, an increase in lactic acid and the radiograph showed a small stomach fixed and without peristalsis. The history dated back only to last July. He had lost 40 pounds in weight, was quite cachectic; there had been no hemorrhage and no pain. The rapid development of symptoms suggested malignant growth involving the stomach only. After thoroughly acquainting the patient with the seriousness of the operation Dr. Morris removed the stomach, finding it small, hard, and wholly œdematous. He did not consider the glands in the vicinity of the stomach to be enlarged. The specimen showed adenocarcinoma of the stomach, with an area of especially marked œdema extending along the entire lesser curvature and showing a small malignant area at the pyloric end.



## FRACTURE-DISLOCATION OF CERVICAL SPINE

DR. S. F. MATHEWS reported a case somewhat similar to those reported by Dr. Torek. On the removal of the pylorus the laboratory reported a condition of chronic ulcer, but later, carcinoma having been found in the lymph-nodes a reëxamination of the periphery of the ulcer showed undoubted carcinoma at one spot.

DR. FRANZ TOREK stated that about the time he operated upon the two cases reported he had another case of duodenal ulcer which on operation showed the same appearance as described for the gastric ulcers, that is the ulcer had an indurated base and he therefore considered it suspicious and excised it. Although the macroscopic appearance was similar to that of the gastric ulcers the microscopic examination showed no carcinomatous change, and he cited this instance as another proof of the well-known theory that whereas carcinomatous degeneration in ulcers of the stomach must be looked forward to, carcinomatous degeneration of duodenal ulcers is practically unknown.

## FRACTURE-DISLOCATION OF THE CERVICAL SPINE

DR. A. S. TAYLOR presented a man, with the history that eight years ago he was thrown from a horse and was completely paralyzed from the waist down with loss of sphincteric control for three months. At the end of that time, as a result of electricity and massage, he recovered and remained well until January 19, 1917, when while working on the road he was struck by a trolley car and knocked down into an excavation. He could not tell how he landed and was taken to the Fordham Hospital in an unconscious condition. There were lacerations of his head, his nose was broken, and he was suffering from contusions all over his body. He recovered consciousness in twenty-four hours, and at that time his only complaint was a severe pain in the back of the neck, which became steadily worse. An X-ray picture of the skull showed no fractures; there had been bleeding from the nose and mouth when he was first brought into the hospital. On the 19th of February, one month after his admission to the hospital, he first came under Dr. Taylor's observation. At this time physical examination showed his eye reflexes normal. There was no Babinski, his gait and station were normal and there was no evidence of injury to the spinal cord. Rotation of the head was limited and caused excessive pain in the lower part of the neck on the left side. The neurologist who examined him located the source of pain pretty definitely in the posterior sixth cervical root, and an X-ray taken of his cervical spine disclosed a fracture dislocation between the fifth and sixth cervical vertebrae. With neurologic examination limiting the difficulty to the sixth root and with the above X-ray findings it seemed fair to do a division of the posterior sixth root of the left side to relieve the pain. Therefore on the 23d of February, a month and four days after the accident, Dr. Taylor did a left hemi-laminectomy, and divided the sixth posterior root. This resulted in complete relief from pain. At some point in the operation, however, there had been sufficient pressure upon the cord to cause practically a quadriplegia which persisted for seven days: there then appeared a little motion in the right foot, followed by motion in the

left foot, finally motion in the arms. After five months of steady improvement the patient was discharged and given a position in the hospital in order to continue with his massage. He now shows no loss of function except in the left hand, where he has a typical ulnar paralysis deformity.

Dr. Taylor called attention to special points shown in this case, stating that in any case where there has been injury to the spine, where there has been very consistent severe pain always located in one spot, he considered it incumbent to have X-ray pictures made of the spine because it is common to have injuries of the spinal column which do not give cord symptoms, but which if neglected will give a great deal of trouble at a later date.

#### FRACTURE OF THE CERVICAL SPINE TREATED BY LAMINECTOMY

DR. CHARLES A. ELSBERG presented a woman who had been injured by a fall out of a hammock, resulting in complete quadriplegia at the level of the fourth and fifth cervical vertebræ. Surgical intervention was delayed for four or five days; during this time the condition became worse but she had some signs of sensation in one upper and one lower extremity, and some reflexes returned. Dr. Elsberg then did a wide decompressive laminectomy and divided one nerve root that was crushed. Dr. Elsberg advised this procedure in order to prevent subsequent root pains and stated that the same held good for nerve roots pressed on by tumors, in which case he considered it was advisable to divide the root if it was a posterior root. He stated that the case presented had gone to a very satisfactory recovery from complete paraplegia of the lower extremities with loss of power in one upper and considerable loss in the other upper extremity. The case presented at the present time only slight ankle-clonus in one lower limb and some deep pressure disturbance in one arm.

#### FRACTURE OF THE SPINE WITH CORD SYMPTOMS

DR. CHARLES A. ELSBERG read a paper with the above title for which see page 63.

DR. WILLY MEYER stated that he had followed more or less the principle of conservative treatment in recent fractures of the spine and had seen a number of cases with symptoms that first seemed to be very serious gradually improve. He had believed these to be cases in which a large effusion of blood had occurred within the spinal canal and that improvement was in part due to its gradual absorption. He felt that after Dr. Elsberg's lucid explanation derived from his large experience his own experience did not warrant his presenting a difference in opinion. He was much interested in the statement that if there is no transverse lesion and the cord is not completely destroyed one should in every instance operate at once.

DR. A. S. TAYLOR agreed with Dr. Elsberg in his statement that one should not operate in complete transverse lesions or in conditions simulating them. He stated that several experiences at the Fordham Hospital convinced him that fractures in the cervical area with symptoms of transverse lesions should never be touched. He reported three cases, occurring in one

service, of fractures in the lower cervical region where the patients were in bad shape but were getting on, maintaining a fairly level condition in their general ill-being, all of whom died within twenty-four hours of operation. These patients had lived from three to four days awaiting neurological examination, and in each a wide laminectomy was done with the cord exposed well above and well below the immediate area of the lesion, but just as soon as the dura was split, in each of them the cord simply "mushed" out of the split like a custard. He believed this to be the cause of the promptly following death. Doctor Taylor did not agree with Doctor Elsberg in regard to the mild-symptom cases, and, although his experience had not been nearly so great, he cited two cases where non-operative treatment in one case gave a prompt and complete recovery in one young man of nineteen who had, in diving through the surf, had a fracture dislocation of the fifth cervical vertebra; at the end of the fourth or fifth day there was some return of reflexes and motion. X-ray showed displacement of the fifth forward on the sixth for three-eighths of an inch. An attempt was made to pull his neck out straight by extreme traction and to put a plaster collar on to hold his neck in a proper position and to give him extension both longitudinally and slightly posteriorly. At the end of a year there remained only a little disturbance of sensation in the tip of the right index finger. He was able to dance and swim and to drive his car. This patient had shown symptoms not of a complete transverse lesion but of a fairly severe one, and still non-operative treatment gave a perfect result. The second instance was a recent case of fracture of the second lumbar vertebra chiefly of the body. There was complete paraplegia below that level but at the end of a week or ten days there was return of sensation and partial return of sphincter control of bladder and rectum. Doctor Taylor stated that with so limited a number of cases as two it was impossible to make a hard and fast rule against operating on every one of his cases of fracture dislocation with only mild degree symptoms, but he did not believe that one should rush too promptly to operation in cases of mild degree symptoms.

Dr. Taylor called attention to a point in hospital technic which he considered might have an immediate bearing upon the progress in these spinal cord injuries. If one sees a broken back brought into the hospital, taken to the operating room, put on the table by the ordinary hospital orderly or other attendants one sees a thousand chances of doubling the already severe injury in transverse lesion of the cord. He stated that even a good house staff has no conception of what it means to handle a broken back. After an anæsthetization the patient is again turned on his face for operation, and once more turned back when put to bed. He stated that these many changes of position lead him to believe that more damage would accrue to the patient than would result in relief as the result of early operation. He suggested that he thought it wiser to wait until bone has formed to give a certain amount of rigidity to the broken spine when the handling necessary to operation could be better borne by the patient.

# TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

*Stated Meeting held October 1, 1917*

The President, DR. CHARLES H. FRAZIER, in the Chair

## CONGENITAL CLEFTS OF THE FACE

DR. JOHN B. ROBERTS presented a boy, three years of age, who was born with a unilateral cleft of the mouth at the right side, with minor vertical clefts of the upper lip and lower eyelids (Fig. 1).

The lateral cleft of the cheek at mouth is now closed by two operations done during the last few weeks (Fig. 2). The scar has not as yet become entirely smooth because the last stitches were taken out only yesterday. In closing these fissures from the corner of the mouth he had found it very important to take deep sutures a considerable distance from the edge of the cleft, because it is almost impossible to prevent infection from the saliva; and feeding and crying tend to tear out the sutures.

The first operation was done by simply paring off the mucous membrane of the cleft and inserting copper wire sutures from skin into mouth. About two-thirds of the cleft healed, leaving the mouth still a little prolonged and its corner turned up, giving the appearance of risibility. By a second operation at the corner, the tissues were so displaced as to make the two ends of the mouth almost the same in appearance. When the scar fades, his mouth will be quite symmetrical. The partial clefts in jaw of right side, and in the upper lip on left side, and the clefts in the lower eyelids are conspicuous. The mouth on the right side showed a lateral cleft before operation about one-third of an inch long. There was a slight atrophy of the right side of the face. This caused the cleft at the right side of the mouth to be directed a little obliquely upward.

From the end of the right cleft there is a shallow groove running upward and outward toward the outer canthus. This corresponds to a want of development in the right maxilla, in which a groove can be felt by pressure through the cheek. Inspection of the mouth shows a corresponding groove in the alveolus in front of the first molar, which is just coming through the gum.

The upper jaw on left side has a nodule below the orbital ridge just outside the usual exit of the infra-orbital nerve. Just above this nodule and corresponding with the position of the imperfection of the upper jaw is a notch in the lower lid about one-sixth of an inch from the inner canthus. Here the skin lines the floor of the notch and is continued as a band over the mucosa until it reaches the conjunctiva covering the sclera. There is then an extension of the band, triangular in shape, running up to the cornea upon the conjunctiva and an attachment within the anterior chamber to the edge of the iris at the pupil. The jaw on the left side appears to be normal. The cleft on the right side gave the child a laughing expression because the lower

lip extended around and upward and showed more mucous membrane than the upper lip. The two lips did not come quite together, exposing some of the upper teeth, giving the child a snarling expression and the mouth an oblique appearance, partly due to a want of development of the right side. The roof of the mouth shows an anteroposterior elevation running from front to back, corresponding to the curious fissure in the right maxilla. There is no cleft of uvula or palate. The uncomely expression has been much improved by the mouth operation.

The upper lip shows on its edge to the left of the median line a slight notch in the vermilion border and a groove in the muscle under the skin which runs up to the left nostril. The skin is normal. This congenital condition is due to an imperfect coalescence of the tissues in the embryo, the same in nature as, but less complete than, harelip. The boy's ears, penis and skull are normal, except that as already stated the maxillæ have some peculiarities.

Dr. Roberts also showed a wet specimen from the Mütter Surgical Museum, being an infant with bilateral cleft of the mouth. In this case Dr. Roberts operated soon after birth, on the right side, but the sutures had not sufficient hold to prevent them being torn out when the infant cried, because the suppuration occurring softened the tissues. Thus a very great strain occurred, particularly as only one side was operated upon. The result was that no union occurred. He should have taken a larger grasp of tissue in the sutures and have operated on both sides at the same time. While waiting for the general condition of the baby to improve it died from debility. The specimen shows the great gaping mouth stretching on both sides far out toward the ears.

He also showed the photograph of a child, three months old, with a facial cleft involving the left side of nose and the inner end of the left lower eyelid. The left ala of nose, part, if not all, of the lachrymal bone, and the intervening structures are congenitally absent. The lower border of the lachrymal lake and its floor are absent, though the orifice of the inferior canaliculus is seen at the angle of the part of the lower eyelid which exists. The tears run directly down into the cavity of the nose, because there is no upper part of the nasal duct. The absence of a lachrymal bony wall, made normally by the lachrymal bone, deprives the child of a bony channel at the orbital end.

To close this gap in the nose, he cut a flap from the left cheek with its pedicle just below the lower margin of the mandible, containing, he hoped, the facial artery uninjured. It was an error of judgment, perhaps, to try to close the whole opening at one operation, for the flap which was slid toward the median line and stitched to the raw edge of the cleft sloughed. Had he transferred a shorter flap with its pedicle near the angle of the mouth and closed first only the lower two-thirds of the opening, possibly this anæmic gangrene would not have occurred.

Akin to these vertical fissures in the face, due to non-closure of the embryonic fronto-oral bud with the lateral buds, are the congenital clefts in the upper lip and palate. These may leave the lip incomplete on one or both

sides of the median line, or divide alveolus and hard and soft palate. The extent and combinations of these orolabial fissures vary greatly. He once saw the bony palate incomplete at or near the middle line of the roof of the mouth, though the fissure was covered with normal mucous membrane. It showed plainly when the patient took a deep inhalation, through an open mouth, by the mucosa sinking into an anteroposterior furrow in the bone. He has now under observation a girl of about ten years, who has the flattened nostril and a notch in the edge of the lower lip sometimes seen after imperfectly repaired complete harelip and cleft alveolus. There is even a little continuation of red mucosa running up the lip on one side of the notch, similar to that seen occasionally after inaccurate adjustment of the edge by the operator. The photograph of this girl (Fig. 6) looks as if she had complete cleft of hard and soft palate, but the deformity is caused by the deep triangular arch of the palate shutting out the light and giving a black shadow.

There is no opening through the palate for even a probe. There exists a coalescence of two incisors, a curious deformity of both clavicles and a duplex great toe on one foot. The impression of the mouth made by Dr. J. V. Mershon shows well the curious anomaly. The child keeps the mouth open constantly, due to mouth-breathing and the impossibility now of closing her mouth because the posterior teeth strike. The lower jaw is not contracted. She also has defective vision and some nystagmus. Adenoid tissue on the nasopharynx and the tonsils has recently been removed.

The wide nostril and flattened nose of complete cleft of palate, alveolus and lip before operation are well illustrated in Figs. 8 and 9, taken before treatment, when the babies were a few weeks old. The projection of the intermaxilla occurring in some patients with bilateral cleft of palate, alveolus, and lip is shown in Fig. 10.

The ten-year-old girl (Fig. 6) looks as though the early fetal structures of palate, lip and alveolus had failed to unite until much later than usual; and then Nature had found it too late to make a good repair of the separated bones and undeveloped parts. Dental and surgical methods will be required for several years.

In Fig. 11 will be seen in a boy, 14 months old, who had cleft-lip and moderate cleft of palate, a notched appearance where the lip did not entirely unite, when operated upon a few weeks before the photograph was taken. The suture punctures have not yet become inconspicuous. This notch somewhat resembles the congenital deficiency in the upper lip of the little boy with bilateral cleft of the cheeks, shown in Fig. 1.

#### OPERATIVE SUGGESTION FOR WIDE BILATERAL CLEFT PALATE

DR. JOHN B. ROBERTS remarked that wide bilateral clefts of the hard palate, in mouths with low arch, present unusual operative difficulty. Mucoperiosteal flaps, to be united across the gap without dangerous tension, and yet with the necessary broad contact of raw surfaces, may be unobtainable by the usual procedures. He recently had employed, in a very troublesome instance of complete double palatolabial fissure in an infant, a modification of



FIG. 1.—Lateral cleft of cheek and vertical cleft of upper lip and of lower eyelid.



FIG. 2.—Operative result in the case shown in Fig. 1.



FIG. 3.—Macrostoma bilateral cleft cheeks, congenital. Front view.



FIG. 4.—Bilateral cleft of cheeks. Lateral view of Fig. 3.



FIG. 5.—Facial cleft involving nose and eyelid. Outline of flap shown.



FIG. 6.—Congenital deformity with fused incisors and very high arch of palate.



FIG. 7.—Plastic cast of palate of case shown in Fig. 6.



FIG. 8.—Wide nostril and flattened nose in unilateral complete cleft of palate, alveolus and lip.



FIG. 9.—Wide nostrils and flattened nose in bilateral complete cleft of palate, alveolus and lip.



FIG. 10.—Projecting intermaxillary bone in cleft of palate, alveolus and lip (bilateral).



FIG. 11.—Notch in upper lip left after imperfect operation for closing a cleft of lip with cleft of palate on one side.



FIG. 12.—Diagrammatic illustration of method employed. (Photograph was not taken from patient who was treated by the method.) The flap outlined on the patient's left is upset towards the median line, the other flap is turned across the gap in the roof of the mouth and its end is sutured on top of the end of the upset flap.





FIG. 13.—Tie beams through cheeks to approximate the separated palatal masses in bilateral clefts of palate, alveolus and lip. Pads of gauze are shown under wires carried through cheeks.



FIG. 14.—Showing result secured of lip in the case shown in Fig. 13.

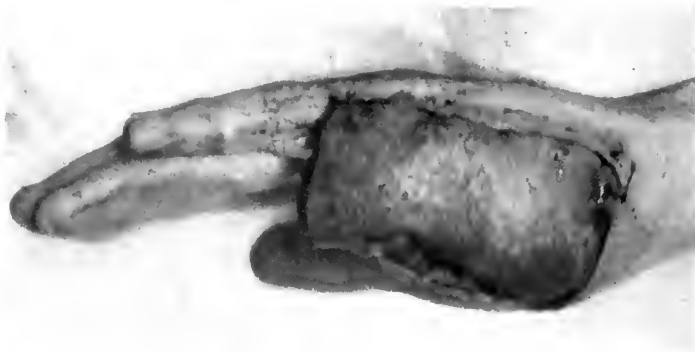


FIG. 15.—Plastic transplantation of cellulocutaneous flap from thigh or abdomen to face in plastic repair of nose, lips or chin. Hand showing skin surface of flap taken from thigh and satisfactorily used in rhinoplasty for syphilitic deformity of nose (Polyclinic patient). Note suture scars where flap has grown fast to ulnar side of hand. Opposite edge of flap shows thick pad of adipose tissue under skin. This border was sewed against raw surface of face, and the band cut loose from other border of flap two weeks later.

## BILATERAL CLEFT PALATE

the usual methods, which, so far as he knew, had not been employed by operators, with whose uranoplastic work he was familiar. It is a sort of combination of Lane's method with the Davies-Colley principle.

On the left side, he dissected up a tongue-shaped flap from the top of the alveolus and the adjoining palatal surface, with its pedicle containing the posterior palatine vessels. The median incision extended along the margin of the cleft backwards to a point a little beyond the posterior edge of the palate plate of the palate bone. The external incision, somewhat parallel to this, was made between the outer surface of the alveolus and the cheek. These two cuts were joined by a transverse cut across the gum and palate not far from the anterior end of the cleft alveolus on the same side. The long flap so outlined was raised by peeling, with a dull raspatory, the mucosa and periosteum from the top of the bony structures, leaving the unruptured teeth and bared bone exposed. By carrying the buccal cut further backward than the median one, the mucoperiosteal flap torn up from the underlying bones was upset, as in Lane's operation, to present its mucous surface toward the cavity of the mouth. On the right side of the mouth a flap, similar in shape, was raised from alveolar and palatal structures, with its pedicle, however, in front, so as to include the blood supply from the anterior vessels of the palate external to the right side of the cleft. This flap, as was the left flap, was torn from the top of the alveolus and palate and included both mucosa and periosteum. Care was taken to lift both these flaps without using an edged tool under them. So-called palate knives with sharp edge or point are a delusion and a snare in raising flaps in uranoplasty. Curved or angular instruments without cutting edges are necessary to avoid dividing the vessels by which blood supply of the flaps is maintained.

The end of the second flap was slipped or drawn obliquely across the bilateral cleft in the roof of the mouth and laid upon the upset flap from the other side of the gap. Four or five mattress sutures of silver wire brought the raw surfaces in close contact over a considerable extent of surface. The eversion of the posterior flap required the incision on its outer side to be carried further backward than the median cut. It may be carried inward a little at its back, to facilitate the turning over of the flap. The anterior flap may need its external incision carried forwards a little to permit rotation at its base. In both instances care must be observed to put no tension on the pedicle which may compress the vessels and cut off the circulation in the flaps. The free ends of both flaps should be made broad, to give wide contact when sutures are inserted in the overlapping ends of the flaps. An oblique bridge is made across the wide gap in the roof of the mouth by this operation, which gives a start for further operative plastic work.

The case in which he used this method a few weeks ago has now a substantial bridge. The child had double cleft of the soft and hard palate, alveolus and lip, with projection of the intermaxillary bone. When he was about two weeks old, Dr. Roberts had pushed back the intermaxillary protrusion, after excising a V-shaped piece of the nasal septum, and wired the alveolus on both sides to the intermaxilla. The tension caused the wire to

cut out and the accompanying closure of the two clefts in the upper lip was followed by suppuration and absolute failure. Twice more an endeavor was made to remedy the lip clefts by plastic operation. On one of these occasions the child developed erysipelas, which spread over head and back and was accompanied by double otitis media. The boy at the time of the final operation was about five months old.

His general condition is now good and it is Dr. Roberts' intention to operate for further closure of the anterior part of the palate in about two weeks. This he shall probably do by the method described to the Academy about a year ago; that is to carry wire sutures through the skin of the cheeks to perforate the two maxillæ and draw the soft bones together in front by twisting the wires on the cheek, much as Brophy does, with intra-oral tie-beams and lead plates within the cheeks (see Figs. 13 and 14).

In great absence of tissue in lips or nose the surgeon may obtain tissue from abdomen or thigh by using hand as transporting agent (see Fig. 15).

#### PEDICLED ABDOMINAL TRANSPLANT FOR CONTRACTURE OF FINGER

DR. P. G. SKILLERN, JR., presented a boy, aged twelve years, who was admitted to the Polyclinic Hospital (Case Record No. 31562), service of Dr. G. P. Müller, on June 26, 1917. Two months before admission he picked at a callus on the palmar aspect of the base of the right middle finger. Infection followed. The abscess was incised by another surgeon, the incision extending in the midline from the middle of the second phalanx across the two proximal flexion creases of the finger to its root. After healing had taken place contraction of the scar followed and went on until the finger was drawn down toward the palm, preventing forcible extension. This median scar was ridge-like and consisted of keloid cicatricial tissue.

June 27, 1917, under local novocaine anæsthesia, Dr. Skillern excised the scar in a rectangular manner, exposing unopened sheath of flexor tendons; the raw surface was covered by an abdominal flap which was stitched to the edges of the wound in the finger. Dressing applied. Limb bound to side.

July 9, 1917, the base of the flap was severed and the flap tacked down into the proximal portion of the skin wound. The abdominal wound was closed. The transplant healed soundly in place; at first redundant it is now growing smaller and adapting itself to the size of the finger. It forms a soft cushion covering the front of the proximal phalanx. It in no way incommodes the patient. The patient has recovered complete function, with the exception of the power of hyperextension.

Dr. Skillern remarked that this case illustrates the teaching of the late Dr. John B. Murphy, that an incision should never be made across a flexion crease. Progressive contraction is the inevitable result. It also shows the method of effectively correcting the deformity, namely, by a pedicled transplant. A copious blood-supply to this graft was insured by aiming to have the superficial epigastric artery in the middle of the pedicled transplant during the twelve days the latter was "taking."

DR. A. BRUCE GILL said that about four months ago he had a case some-

## TRANSVERSE INCISION FOR ACUTE APPENDICITIS

what similar to that reported by Dr. Skillern. A man, forty-seven years old, a leather-worker, had cut the middle finger on his left hand on a fence twelve years previously. The finger had become contracted so that it interfered seriously with his work. Dr. Gill excised the scar tissue which extended from the palmar crease to beyond the proximal interphalangeal joint. It was then found that the flexor tendons were contracted. They were lengthened. The proximal interphalangeal joint could now be extended and flexed by force, but it moved with a snap, as all the soft structures about the joint were contracted. Therefore, about three-eighths to one-half inch was removed from the distal end of the proximal phalanx to allow free motion in the joint.

The pouch of skin behind this joint was used in part to cover the joint in front. The remaining area of the wound was covered with a pedicled skin graft from the thigh. The hand was held to the thigh in a comfortable position by a light plaster case in which a window was cut for the dressing of the wound. Union had taken place at the end of two weeks and the graft was then cut loose from the thigh.

Contraction and thickening of such a graft always occurs. This makes a thick pad of skin on the hand which may interfere with the work of the patient and which is unsightly. In time the thickness of the graft becomes much less. In the case here reported he proposed to perform a second plastic operation to reduce the thickness of the graft.

DR. JOHN B. ROBERTS said that he had used the pedicled flap in the hand after excising Dupuytren's contraction. A cushion of skin and fascia remains somewhat as in this case. It would be easy to excise a piece and lessen the bulk as suggested by Dr. Gill. He had used in partial rhinoplasty the method of obtaining the flap described by Dr. Skillern. An abdominal or femoral flap is fastened to the ulnar edge of the hand, on which the surgeon has made an incision and laid the edges apart, so as to expose the underlying tissues for a half inch in width and two or three inches in length. After two weeks the thick flap of skin and superficial fascia is cut loose from the thigh or abdomen (Fig. 14). Then the hand is placed close to the face and the free edge of the cellulocutaneous flap stitched to the border of the raw surface previously prepared in the nasal or oral region. Two weeks later the hand is cut loose from the flap which remains fastened to the face, and later is modelled to repair nose, lip, or chin. One can also obtain in this way tissue for plastic repair of the lip or chin by attaching a flap to hand and later applying it to face. Many amputations of fingers can be avoided by taking skin from the abdominal wall to cover the bones in the manner so well described by Dr. Skillern. He was convinced that many fingers have been needlessly sacrificed.

## THE TRANSVERSE (DAVIS) INCISION FOR ACUTE APPENDICITIS, WITH SPECIAL REFERENCE TO THE APPENDIX CHAMBER

DR. P. G. SKILLERN, JR., reported the following cases:

Case I is a boy, twelve years of age, who had perforative appendicitis, for which the entire operation was done under novocaine anæsthesia, using a  $\frac{1}{2}$

per cent. solution without adrenalin. The boy had been sick for five days with pain (at first referred to navel, soon localizing in right iliac fossa) followed by nausea and vomiting, fever ( $99\frac{2}{5}^{\circ}$  F.) and leukocytosis (16,500). There were moderate rigidity of the right rectus and right flank muscles, acute tenderness on pressure between spinonavel line and Poupart's ligament, and induration in pelvis as revealed by rectal palpation. The incision began  $\frac{1}{4}$  inch to inner side of anterior superior iliac spine and passed horizontally across to the midline—a distance of about 4 inches. The anterior sheath of the rectus muscle was cut across and the muscle retracted inward. The linea semilunaris and the posterior sheath of the rectus (close to Douglas's semilunar fold) were divided. The external oblique aponeurosis and the internal oblique and transversalis muscle aponeuroses and muscular fibres were separated with the fingers out to the iliac spine. The transversalis fascia and peritoneum were divided transversely between forceps. The anterior wall of the cæcum presented itself and prolapsed through the wound. With the finger the appendix was traced to its tip, which lay in the pelvis amidst coils of ileum, which formed the left wall of the abscess cavity, as well as the upper wall, the right wall being formed by the cæcum and side of the pelvis. The appendix was perforated near its tip. The appendiceal vein was the seat of thrombophlebitis, feeling like a match-stick. Drainage consisted of one Mikulicz and one rubber tube: these drains were brought out through the lateral angle of the incision close to the anterior superior iliac spine, and between the pelvis and their point of emergence were bounded above by the cæcum and below by the iliac fossa. Wound sutured in tiers up to drainage.

Owing to the thrombophlebitis of the appendiceal vein, which was found at operation, this patient was kept in bed until the danger of ascending infection of the portal venous system or detachment of an embolus from the thrombus had passed. This thrombophlebitis process maintained an irregular fever for three weeks, and when the fever finally abated and the leukocyte count fell to normal, it was presumed that the thrombus had become organized, so that the patient was allowed out of bed at the end of the fourth week. The wound is firmly healed; there is not the slightest suggestion of a weak spot in the scar.

In Cases II and III, when relaxed by ether, a definite mass the size of a plum could be felt in both just above the outer half of Poupart's ligament. The transverse incision in its outer portion gave a very satisfactory free exposure of the mass, which in each instance proved to be the acutely inflamed and distended appendix surrounded by fresh plastic lymph exudate and wrapped by the acutely inflamed and hyperplastic omental edge. This mass was contained in a little chamber bounded in front by the anterior abdominal wall; behind by the iliac fossa; externally by the lateral abdominal wall; internally by the terminal coil of ileum and meso-appendix; below by Poupart's ligament; and above and in front by the towering cæcum, which is usually covered by the omentum.

This *appendix chamber* as it should be called—just as Birmingham in

Cunningham's "Anatomy" speaks of the "stomach chamber"—adds a very forceful argument in favor of the transverse incision for acute appendicitis. The danger zones of this appendix chamber are the upper wall and the inner wall. The upper wall is usually—except in children and in those with thin, short and poorly developed omental aprons—effectively sealed by the omentum, whose edge swells up with an army of phagocytes and offers an impenetrable front to the spread of infection in the upward and forward direction. The inner wall is the most vulnerable because unreliably sealed by the hyperplastic meso-appendix and the terminal and other coils of ileum: the pelvic cavity, too, forms a safety outlet or sewer for toxic exudates, and to this extent compensates for the deficiency of the inner wall. In the usual case of appendicitis with abscess, therefore, the safest approach to the appendix chamber is from below, in front, and externally, and this zone corresponds to the safest and most effective drainage outlet for the appendix chamber. This drainage track extends from the bottom of Douglas's cul-de-sac outward between the cæcum above and Poupart's ligament below to near the anterior superior iliac spine, just below and to the inner side of which it emerges. When operating under local anæsthesia one can see the internal oblique muscle by its contractions grasp the drainage material snugly with a soft pad of muscle tissue, and here at the very close of the operation one sees inaugurated that very effective mechanism that prevents post-operative hernia and that forms the principles upon which McBurney's gridiron incision is based, namely, to separate the muscles in the direction of their fibres and to push aside without injury the motor nerves.

The vertical incision through the right rectus is objectionable in the first instance because it necessitates approaching the appendix chamber from within outward, thus entering the chamber by breaking through its inner defensive wall, thereby exposing the general peritoneal cavity to diffuse infection. Drainage through a right rectus incision is by no means ideal: it occupies an undesirable relationship with both the appendix chamber and the general peritoneal cavity. Again, the vertical incision is objectionable because it violates the McBurney incision principles: it cuts across the muscles and cuts across the nerves. Strictly speaking it does not divide the muscle fibres, but it divides the tendon fibres, which form the rectus sheaths. These aponeurotic tendon sheets are formed by minute tendon units which run transversely, and as a practical surgical proposition it is just as noxious to cut across tendons as it is to cut across muscle fibres. When the operator comes to sew up the vertical wound he may notice when closing the posterior rectus sheath that the sutures tend to cut through and pull out toward the incision in the sheath. Post-operative intestinal distention puts an immediate strain upon the posterior rectus sheath, causing a little gap between every pair of suture holes, and forcing through each gap a pellet of subperitoneal fat—a condition that gives rise to much of the scar discomfort which is often erroneously attributed to the presence of adhesions. This undesirable feature of the vertical incision can be obviated by imbricating the posterior rectus

sheath, but this is technically difficult and time-consuming. With the vertical incision it is impossible to avoid contusing, lacerating, or even dividing the motor nerves, unless one can work through a very short vertical incision, in which case the nerve or two exposed in the field may be gently drawn aside. It must be acknowledged, however, that division of these nerves so close to their termination is not so damaging as their more external division, for in the former instance the inner strip of the rectus is all that can be paralyzed. Drainage through a vertical incision is more liable to result in post-operative ventral hernia than drainage through a transverse incision. From the cosmetic standpoint the vertical incision scar is liable to become unsightly, while on the other hand—unless keloid change supervenes—the transverse incision scar eventually becomes almost imperceptible, for the natural tendency of the superficial layers of the abdominal wall is to fall into transverse creases, just as is the case with the skin covering the neck.

In concluding these observations he again called attention to the appendix chamber which he had described, feeling that its consideration from the surgical standpoint forms a basis not only for the rational method of dealing with the usual case of acute appendicitis with abscess, but also for one of the arguments favoring the transverse incision. In addition, the transverse incision is anatomically, physiologically, pathologically and cosmetically far superior to the vertical incision. In closing up the transverse incision it will be noted that the undivided rectus muscle falls across the inner half of the wound, forming a perfect barrier against hernia through this portion. Finally, the treacherous deep epigastric artery can be freely exposed and retracted inward out of harm's way when the transverse incision is employed, whereas with the vertical incision it is neither so easily revealed nor so readily avoided, and when divided it is capable of giving rise to very troublesome bleeding and even to death from post-operative hemorrhage (see article by the reporter in *ANNALS OF SURGERY*, April, 1917, 451).

DR. GEORGE P. MÜLLER agreed with Dr. Skillern in objecting to the vertical right rectus incision in acute appendicitis, and for the same reason. He used the McBurney incision almost entirely and had no difficulty in handling the pathology within the abdomen. The opening can be made as small or as large as wished, and if the suggestion of Judd is followed and the rectus muscle exposed, it can be so pulled inwards as to give a very large exposure. He did not see that there was anything materially different in the transverse incision from the McBurney incision because it does not matter which way the skin is cut. He never used the McBurney incision in chronic cases where there might be duodenal ulcer above or pelvic disease below.

DR. GWILYM G. DAVIS said that he was interested at the time this incision was proposed to find out what was the favorite incision in appendicitis. From the fact that in this neighborhood the longitudinal incision alongside the rectus was used so much he assumed that that might be the favorite incision everywhere. He found, however, upon inquiry, that the favorite incision was that of McBurney. At a surgical meeting he once saw a demonstration of McBurney's operation in which a surgeon thought the case was



not a suppurative one, but in which it turned out to be such. The exposure which he obtained on that occasion did not impress him favorably. He even yet could hardly see why the McBurney incision for suppurative cases is considered a really desirable one. He had always preferred the method which Dr. Skillern had described. The incision for the subacute cases can be made quite small. If, however, a supposedly mild appendicitis turn out to be otherwise, presenting adhesions or other difficulties, unless one has a good exposure one may perforate and tear the intestines. The small incision can then be enlarged by splitting the sheath of the rectus transversely over the muscle fibres clear across. It may be split to the median line, giving then an incision extending from the median line over to the anterior superior spine. If necessary it can be carried still along the crest of the ilium. With such an incision the surgeon can insert the hand and reach into the pelvis. If an operation on the gall-bladder is required, personally, he preferred to close the transverse incision opposite the anterior superior spine and make a separate incision above rather than to make one extremely long cut to expose both localities.

DR. EDWARD MARTIN said that this muscle-splitting operation which Dr. Skillern describes, he, together with many other surgeons, had been using for many years. The advantage of the transverse skin cut is, of course, incident to the fact that changes in custom are constantly occurring and there may come a day when a scar in this region may be conspicuously disfiguring. The method of approach is satisfactory in nearly all cases.

#### FACIAL CARBUNCLE, SINUS THROMBOSIS

DR. WM. J. RYAN said that the cavernous sinus, though less frequently affected with thrombosis than the other large sinuses, may become infected through the veins even though the seat of the trouble is apparently far removed. Such infection occurs by way of the extra-orbital connections of the ophthalmic veins, the superior and inferior, from cancrum oris, alveolo-dental periostitis, etc., which are also in communication with the facial veins.<sup>1</sup> Thus carbuncle of the face may be followed by cavernous sinus thrombosis. In the presence of thrombosis of the cavernous sinus two groups of pressure symptoms may be present: (a) venous, causing exophthalmos, œdema of the lids and of the corresponding side of the root of the nose, and chemosis; (b) nervous, causing ptosis, strabismus and variations of the pupil, pain, etc.

In illustration he reported a case taken from the records of the service of Dr. George P. Müller in the St. Agnes Hospital. The patient was a girl, nineteen years of age, who was admitted on February 7, 1917, with swelling and redness of the upper lip, swelling and œdema of both cheeks and of the right submaxillary region.

Five days before admission she noticed a pimple on the skin surface of the upper lip. She did not remember picking it. The lip became greatly swollen, but not very tender.

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<sup>1</sup> Piersol: Human Anatomy.

When admitted the upper lip was hard and swollen and was the seat of numerous pustules. Both eyes and lids were swollen. Both cheeks, especially the right, and the right submaxillary region were hard and brawny. There was also a moderate submaxillary lymphadenitis. Temperature was 102°; pulse 108; respiration 23.

Under ether anæsthesia an incision was made on each side of the midline of the skin surface, and corresponding incisions on the external mucous membrane. No free pus was seen, but the whole lip was a mass of sloughing tissue, with here and there a typical core. The lip was curetted through the four incisions and drained with rubber dam. A rubber coffer-dam was placed between the upper lip and the upper jaw, and allowed to extend over the lower lip so as to prevent any drainage running into the mouth. The whole face, except the eyes, was dressed with saturated magnesium sulphate dressings. The eyes were covered with wet boric acid compresses. The swelling of the face and submaxillary region was markedly reduced in twenty-four hours and had all disappeared the morning of the third day. The lip did not drain much but reduced in size daily until almost normal in contour. At the end of the second day she was somewhat restless. By this time there was some ptosis of the upper right eyelid, but no apparent exophthalmos. During the next day her restlessness did not abate, and that night she became very excitable, so much so as to necessitate the administration of morphine. On February 10, the second day after operation, all external swelling had practically gone, but the right eye was bulging considerably and the inferior palpebral conjunctiva began to avert. Ptosis of the upper lid was not very marked. She responded to conversation and had control of her sphincters (at this time). The next day the patient suddenly became very delirious; she vomited, and voided urine and fæces involuntarily. The dressings were removed from the face and the rubber dam removed from the mouth. The right exophthalmos was greatly increased. The eyelids could not be closed over the eyeballs. About 2 P.M. the patient became unconscious and died at 8.30 that evening.

It is to be regretted that autopsy was not allowed by her family.

#### THE USE OF DICHLORAMINE-T IN THE TREATMENT OF INFECTIONS AND WOUNDS

DR. WALTER E. LEE read a paper with the above title for which see page 14.

DR. PAUL A. LEWIS demonstrated an experiment improvised to emphasize the fact that the Dichloramine-T solution in oil gives off chlorine to water continuously over a number of hours, by taking a solution of starch and potassium iodide and floating the oil solution of Dichloramine-T on its surface. The test for free chlorine is dependent on the exhibition of free iodine; chlorine replaces the iodine in potassium iodide and sets iodine free, which free iodine gives the blue reaction with starch. If one mixes a watery solution containing free chlorine with this it will give immediately and completely the starch reaction for free iodine. It shows that the decomposition

is very gradual and continues for a long time. By adjusting these solutions a little differently one can show that the solution will become progressively more intense in its color during 24 hours.

Early in the spring Dr. Lewis visited Dr. Lee's surgical clinic where he had begun to use Dichloramine-T. The contrast between the condition of his patients and those seen in surgical dispensaries 10 or 15 years ago was so striking that he was convinced that unless some very radical change in surgical technic had taken place there must be something very good in Dichloramine-T. Visits to other clinics showed conclusively that no general advance in methods had taken place. This influenced him to try to oblige first Dr. Lee and Dr. Sweet in a very small way and to try to supply this solution for their use both here and abroad. The requests have increased in number gradually and it has seemed a duty, under the circumstances, for the Phipps Institute to supply what was needed to give a fair and extended trial to the material.

Laboratory men years ago had gradually come to the conclusion that what we know as a general antiseptic could be of little value in the treatment of infectious diseases or infected wounds. They had therefore been turning their attention to what they termed specific or partially specific disinfectants. Salvarsan is the outcome of that general idea. It is really revolutionary from the laboratory man's point of view that chlorine in any form should be found to be applicable in this way because chlorine is a general disinfectant and as such would have been expected to be a general protoplasmic poison; fully as destructive to tissue as to bacteria. It is an agent which destroys everything with which it comes in contact unless carefully controlled. The method of its control had never been developed until Dakin's studies led to the modified Labarraque's solution now known under his name. So adjusted, it has a certain disinfectant value in concentrations which do not destroy tissue. Dichloramine-T is a further advance in the direction of the controlled use of chlorine.

In another respect Dichloramine has been revolutionary. Koch thought that disinfectants in oil were useless. The fact is that this idea was based upon correct observation but it has no general application. Koch found that phenol, a strong disinfectant in water, was much reduced in activity by solution in a vegetable oil. These experiments were used as the basis of the generalization that disinfectants in oil were quite useless. Dichloramine-T shows that this generalization was incorrect and that oily solutions can be expected not only in the instance of Dichloramine-T but in other instances to do a great deal that water solutions will not do. Observations by Professor A. N. Richards and Mr. McMaster, during the past summer, have shown that phenol itself is less active as a disinfectant if dissolved in water than in a mineral oil. The whole question of disinfectants which are soluble in oil will have to be gone over again. We have made only the barest beginning of that work this summer.

Some have said that the Dichloramine-T is not a disinfectant, that all its value is due to the eucalyptol. It is easy to understand that in the present

chaotic condition of the question some one may have done an experiment which has led with more or less propriety to this conclusion. On the other hand, the experiments of Richards and McMaster do not lead to any such conclusion. He did not, however, consider that these experiments are by any means final or conclusive in the particular figures mentioned.

Phenol in a good grade of paraffin oil kills in 0.3 per cent.; eucalyptol fails to kill in 10 per cent. Chlorinated eucalyptol gives no killing in 100 per cent. in 24 hours; it is less active than eucalyptol. Dichloramine-T in solution has given very variable results; dissolved in chlorinated eucalyptol 0.3 per cent. has killed in 24 hours—equivalent to phenol. Dissolved in eucalyptol and paraffin oil in the hands of Richards and McMaster concentrations of from 0.03 per cent. to 0.002 per cent. have killed cultures. There can be no question that Dichloramine-T is a very strong disinfectant.

There is one other question which should be raised. We have no method really of contrasting properly or of stating on the basis of any of our laboratory tests what the therapeutic value of a disinfectant is going to be. The relative activities in test-tube as expressed in phenol coefficient, of course, mean nothing. We should know the relation between the disinfectant value and the amount that can be applied to the tissues, but have no satisfactory way of determining or expressing this. In this respect, without being able to be very precise either as to its exact disinfectant action or its exact ability to affect the tissues, we can say without question that Dichloramine-T is in a practical sense by all odds the strongest disinfectant that we have. We can apply to tissue at least once, and probably twice or three times, a 20 per cent. solution of Dichloramine-T in strong chlorinated eucalyptol. The solution is thus far stronger than phenol in the surgical sense because it is well known that a 5 per cent. solution of phenol cannot be safely applied and that a 1 per cent. solution may lead to gangrene if frequently applied.

CAPT. WM. H. FURNESS, M.R.C., said that for the use of Dichloramine-T in the treatment of contaminated and of infected wounds, the technic which Lieut. E. Lee devised, in contrast to the elaborate technic employed by Dr. Carrel in the use of Dakin's hypochlorite solution, is simplicity itself. The technic embodies, of course, the fundamental principles of surgery and of asepsis; beyond these there is but little required other than a knowledge of the chemical actions and reactions of the dichloramine, which Dr. Paul Lewis has so clearly and concisely demonstrated.

In surgical dispensary work, where all the cases are ambulatory, the treatment with Dichloramine-T can be carried out with such simplicity and system that the time required for a given number of dressings is less than one-third that required for the usual dressings with any of the other antiseptics, and the amount of gauze and of absorbent cotton and the number of bandages necessary is one-eighth of that ordinarily used.

The system consists of dividing up the work into three stages: the patients themselves remove the outer layers of bandage or of adhesive strips before coming up to the dressing table, but they leave in place the innermost dressing which covers the wound. The surgeon removes the inner dressing with

## DICHLORAMINE-T IN WOUNDS

sterile forceps and then gives to the wound whatever attention it may require, such as removing sutures, blotting up excess of secretions, or oozing of blood, etc., and then the nurse, who attends to the sterilization of the instruments also, sprays the oil over the wound from an atomizer; the surgeon renews the four layers of gauze (all that is necessary) over the wound and the patient passes on to an assistant to have the dressing held in place by the fewest possible turns of a gauze bandage. Or the dressing may be held in place by means of short strips of rubber adhesive plaster provided with eyelet-hooks on one end. These strips are placed on either side of the dressing and a light rubber ring is laced across; this not only holds the gauze in place but allows free ventilation to the wounded surface—an important requisite in dichloramine dressings.

With such a system the average time required for the third or fourth day's dressing of the ordinary dispensary wounds is about thirty-five or forty seconds; the whole treatment of the wound is, however, performed with strict attention to asepsis, the surgeon's rubber-gloved hands touching nothing but sterilized instruments, and everything that comes in direct contact with the wounds has been carefully sterilized.

The articles required on the dispensary dressing table are as follows. This number of instruments is found to be necessary in order to keep up a constant rotation between the sterilizer and the trays for sterile and soiled instruments: A small electric or a gas sterilizer. Tray for sterile instruments. Tray for soiled instruments. Instruments: 6 pairs of dissecting forceps, 4 pairs of scissors (2 pairs of sharp points, 2 pairs curved), 2 pairs of hæmostats, 4 grooved directors, 1 Luer syringe with glass pipette, 1 pair sterilizer forceps. A glass atomizer, preferably one with a small reservoir attached directly to the spraying tube. Gauze dressings cut and folded in the following sizes: one and a half by two inches; two and a half by three and a half; and four by six inches. Cotton sponges; these should be, for convenience, about the size of a hickory-nut and wrapped in a single layer of gauze to prevent the cotton fibres from sticking in the wound. Small cotton applicators (on wooden sticks). A small medicine glass. An amber glass, glass-stoppered stock bottle of Dichloramine-T.

DR. GEORGE M. DORRANCE said that in his service at St. Agnes Hospital, they had had great difficulty in carrying out the Carrel method of treatment on account of the frequent changes in their nursing force, and the changes of residents and assistants. Their results, therefore, with the Carrel treatment have not been the results that Dr. Carrel reports. Their technic with the Dichloramine-T has not necessitated this refinement of technic and they have therefore been able to obtain more satisfactory results. Several cases stand out prominent in his mind: First, a knee-joint where half the outer surface of the joint was exposed and the joint was filled with street dirt. The wound was cleansed and a 20 per cent. oil used. The joint now is closed and a limited amount of motion is present. Case II, a stab wound of the pleura, was injected by the interne. This closed by primary union. In skin grafts they had been able to obtain takes in 85 per cent. of the grafts. Burns have

healed more rapidly and with less constitutional symptoms. Compound fractures which were infected and dirty from street dirt have healed more rapidly, and usually without any suppuration. In the smaller wounds, infections are seldom seen and the amount of dressings and dressing time have been greatly diminished.

In the use of this oil, one must not forget to adhere to the usual surgical principles and particularly stop all hemorrhage. A number of patients have complained of the amount of pain, but he does not think it is any greater than one experiences with the average dressing.

#### BIRTH INJURIES OF THE SHOULDER

DR. A. P. C. ASHHURST read a paper with the above title, for which see page 25.

#### GALL-STONE ILEUS

DR. E. J. KLOPP presented a gall-bladder and duodenum, with the following history:

The specimen is from a patient of sixty, who was admitted to the medical wards of the Jefferson Hospital December 15, 1915. She was jaundiced at ten years of age. No history of biliary colic. Has had a good deal of constipation. On December 12, three days prior to admission, she began to have anorexia, followed the next day by severe epigastric cramps which were intensified each time she took food. A high enema was effectual. She vomited frequently. Several purgatives were taken without result. On the day of admission the abdomen was rotund and obese but not distended, slight tenderness in the midline over the epigastrium. Vomiting ceased for five days. Nine days after admission she vomited again and rapidly became worse. She was transferred to the service of Dr. Stewart, to whom he was indebted for the privilege of operating. The abdomen was opened by an incision through the right rectus. A calculus was found in the mid-portion of the jejunum, which was removed through a linear incision of the bowel. The gut above the calculus was distended and dark in color, below it was collapsed and empty. Owing to the grave condition of the patient not much attention was given to the gall-bladder, which was imbedded in a mass of dense adhesions. The abdomen was closed without drainage. The patient died 18 hours after operation. At autopsy the coils of intestine were matted together, but were easily separated. The mid-portion of jejunum showed a neatly approximated suture line 4 cm. extending in long axis of bowel and covered with plastic exudate. Below this point the intestines were collapsed, above it they were distended, lustreless, purplish blue and friable. In the region of the gall-bladder was a mass of adhesions binding the lower surface of the liver, the pylorus and the duodenum together. At the junction of the first and second portions of the duodenum is an opening 3 cm. in diameter from which intestinal contents escape. On the under surface of the liver is a piece of gall-bladder 2 cm. in diameter bound up in adhesions; it has a thick fibrous wall and is empty.

## BOOK REVIEWS

WHITE AND MARTIN'S GENITO-URINARY SURGERY AND VENEREAL DISEASES. Tenth Edition. By EDWARD MARTIN, BENJAMIN A. THOMAS and STIRLING W. MOORHEAD. Octavo, pp. 929, profusely illustrated. J. B. Lippincott Company, 1917.

For twenty years this book of White and Martin has been a recognized authority in the field to which it is restricted. It is practical, full, judicial, accurate and clear, brief but comprehensive. It is a fitting monument to the activities and attainments of its senior author, the late J. William White, to whose memory this latest edition is dedicated.

LEWIS S. PILCHER.

A REFERENCE HANDBOOK OF THE MEDICAL SCIENCES. By various writers. Third edition, edited by THOMAS LATHROP STEDMAN, complete in eight volumes. Imperial quarto, cloth. Illustrated by numerous chromolithographs, half tone and wood engravings. New York: William Wood & Company, 1913-1917.

Volume 8 of this very elaborate and comprehensive encyclopædia is now before us. The present edition has occupied four years in its production. It is now just thirty years since the publication of the first edition was completed under the able editorship of Dr. Albert H. Buck. The onerous duty of supervising a third edition in which much is new material has been very properly shifted by Dr. Buck from his shoulders to those of a younger man. We are glad to note, however, that the veteran editor has not entirely separated himself from this latest edition, but that, particularly in the domain of the History of Medicine and Biography, he has continued his contributions to it.

The title "Reference Handbook" is hardly descriptive of the extensive scope of the work. Under the name "Handbook" we naturally think of a small treatise that may easily be held in the hand. Instead of this, we have here a great quarto, ponderous, encyclopædic, reminding one typographically of the Century Dictionary more than anything else. We are assured by the publishers that previous editions have had a very large sale. This we can readily believe. The reviewer has during these many years often had occasion to refer to it and always with profit and advantage. In the present edition, not only has the matter in the previous edition been thoroughly revised, and in many cases rewritten, but a very large number of new subjects have been introduced and are given more or less extended treatment.

In opening this concluding volume one's attention is at once drawn to the very interesting and comprehensive article on the History of Surgery, from the pen of the veteran Stephen Smith. Especially the very full treatment of the Development of Surgery in America is worthy of note and the

Profession of America should be grateful to Doctor Smith for having left this record of a development in which he might very properly say, "*Magna pars fui.*"

The articles on the Sympathetic Nervous System, upon Syphilis, upon the Thyroid Gland, and the Tonsils, are especially worthy of surgical note.

LEWIS S. PILCHER.

ABSTRACTS OF THE MEDICINE AND SURGERY OF THE WAR. A collection of articles by specialists working at the large base hospitals at the front, most of which have appeared from time to time in various medical journals. These short monographs are designed to allow the practitioner to keep abreast of the rapid strides made in both medicine and surgery in special lines in the Ambulance Hospitals, Base Hospitals and laboratories of the army. Published by Masson & Cie, Paris.

WOUNDS OF THE SKULL AND BRAIN, by C. CHATELIN and T. DE MARTEL, with a preface by Professor Pierre Marie, has recently been published in this Collection. There are 272 pages of text with 97 illustrations. Part I is upon Wounds of the Brain, by Doctor Chatelin, a neurologist, and is based upon his experience with 5000 patients examined and treated in the clinic of Professor Pierre Marie at the Salpêtrière. Part II is upon the surgical aspects of Wounds of the Skull, by Dr. T. De Martel, also an associate of Professor Pierre Marie at Salpêtrière. Many new points both in diagnosis and treatment are elaborated, and the details of the new operative technic and new instruments are fully illustrated.

In this series also has recently appeared a monograph upon FRACTURES OF THE LOWER JAW, by Professor LEON IMBERT and Dr. PIERRE REAL, with a preface by Dr. Ch. Fevier, Medical Inspector General. There are 151 pages, including 97 illustrations and five plate reproductions. Professor Imbert, from the Medical School of Marseille, in collaboration with Doctor Real, Dental Surgeon to the hospitals of Paris, presents the special subject of Fractures of the Lower Jaw in six chapters, covering the etiology, pathological anatomy, diagnosis and symptoms, prosthetic treatment, surgical treatment, and prognosis and end results. The illustrations are numerous.

FRACTURES OF THE ORBIT, by Professor FELIX LAGRANGE, belongs in this new series. There are 222 pages of text, with 77 illustrations and 6 reproductions of plates. This monograph presents the anatomy, types of fractures most common, with the modes of treatment and results. Unlike the two preceding articles, this is mainly a series of case histories illustrating the points of treatment and results obtained.

THE TREATMENT AND RESTORATION OF LESIONS OF THE NERVES, by Madame ATHANASSIO-BENISTY, interne of the Paris Hospitals, with a preface by Professor Pierre Marie, is the second volume upon the subject of nerve lesions by this author, the first volume being entitled Clinical Forms of Nerve Lesions. The present volume includes 178 pages of text with 62 illustrations and four pages of plate reproductions. The subject matter



## BOOK REVIEWS

is concerned with macroscopical and microscopical lesions of the nerves, voluntary restoration of function, electrotherapy, surgical treatment, physiotherapy, orthopædic apparatus, and symptoms, diagnosis, and treatment of various types of paralysis.

A TREATISE ON REGIONAL SURGERY. By various authors, edited by JOHN FAIRBAIRN BINNIE, A.M., C.M., F.A.C.S., Kansas City, Missouri. Philadelphia: P. Blakiston's Son & Co.

The aim of this work is to present short monographs on the injuries and diseases of the different regions of the body. Volume one is written by thirteen different authors. It is stated in the announcement of volume one that there will be chapters upon the Head, the Branchial System, the Thorax and the Breast; and in volume two there will be chapters upon the Abdomen, the Genito-urinary System, and the Spine; and in volume three there will be chapters upon the Upper Extremity and the Lower Extremity. The first two volumes have appeared from the printer.

In so extensive a book, a summary of nearly all of surgery, it is extremely difficult to contribute in a brief book review a clear picture of what each author has covered in the subject assigned. Moreover, it is extremely difficult to form constructive criticism where such a large number of subjects appear in so small a space. Obviously in such a compendium of surgery, even though the separate chapters are pretty complete monographs of the subject in question, there must be a great variation in the quality of the work presented.

It would be aside the mark to criticise the wisdom of undertaking such a tremendous task as the editing of volumes of this sort. Dr. Binnie has chosen for the most part representative men as authors and each one has presented the subject entrusted to him in the form that appealed to him as most attractive.

The chapters in the first volume that deserve especial mention as being particularly well done are those by Joseph Bloodgood upon the Female Breast, and Samuel Robinson upon the Surgery of the Heart, Pericardium and Diaphragm. The three chapters by Charles H. Mayo upon the Thyroid, the Parathyroids, and the Thymus are written and illustrated in an authoritative manner. The chapter by J. E. Thompson upon Inflammatory Infections of the Neck is well done and introduces a new subject in a systematic surgery. J. E. Summers presents the subject of Injuries and Diseases of the Face and Jaw in a simple and instructive fashion.

Volume two, which covers the Abdomen, the Genito-urinary System, and the Spine, is as a whole better done than volume one. There are chapters upon diseases of the abdominal wall, hernia, the stomach and small intestines, the vermiform appendix, the large intestines, intestinal obstruction, the peritoneum and omentum, the rectum and anus, the liver, the pancreas, the spleen, the kidney and ureter, the bladder, the prostate, the external male genitalia, affections of the spinal column, and diseases of the spinal cord.

In glancing through the chapters of the second volume I am very much

## BOOK REVIEWS

struck by the fact that the men who have written these various chapters are the men who have been devoting special attention to these particular subjects. I am also impressed by the fact that these monographs are not exhaustive treatises, but represent the knowledge each surgeon has upon the subject in hand.

Consequently I should say in criticising this book of Binnie's that it is distinctly a summary of the knowledge of individual special men upon each subject contributed. In this sense the surgery is an unusual one, and it is quite representative of American surgery. The volumes represent a group of special monographs written by special men, and in most instances are well conceived and well written.

It may be that it will always be necessary to possess a general surgery that covers all subjects. More and more in the future, I believe, however, that greater dependence will be had upon individual monographs rather than upon a general surgery. The present surgery may well represent the transition between these special monographs and the old-time general surgery in that it attempts to be a combination of both.

CHARLES L. SCUDDER.

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## A STUDY OF ANTE-OPERATIVE AND POST-OPERATIVE BLOOD COUNTS IN NON-INFECTIVE SURGICAL CONDITIONS

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(Under a Grant from the Harriman Research Fund, College of Physicians and Surgeons, Columbia University, N. Y. C.)

THE blood count in acute infective surgical conditions has been of much interest and of great importance in diagnosis and prognosis for some time. Sondern<sup>1</sup> demonstrated its value beyond question by many observations and produced his "resistance line." His findings were very soon confirmed by many observers—Gibson,<sup>2</sup> Wilson,<sup>3</sup> Lampé,<sup>4</sup> and others.

The phenomenon of post-operative leucocytosis which occurs in those cases which have no acute infective process going on, although less frequently observed, should be of interest both to the surgical pathologist and to the operator who endeavors to minimize the injury of an operation.

A number of observers—Chadbourne,<sup>5</sup> Da Costa and Kalteyer,<sup>6</sup> Cabot, Blake and Hubbard<sup>7</sup>—found, some years ago, that there is a leucocytosis following operations under anæsthesia. Each group of men, however, has given a different explanation for the phenomenon. One attributes it chiefly to the anæsthetic; another, to the concentration of blood; a third, to the operation. None of them subjected the phenomenon to the ultimate analysis for obvious reasons—the causative factors may be so numerous that it is impossible to subject human beings, or even animals, to one factor at a time and observe the result of each. A study of any single case, for the same reasons, leads one into a maze of difficulties. It is only by taking a large

TABLE I  
LIST OF OPERATIONS STUDIED

10 inguinal herniæ repair	1 amputation of toe
7 chronic appendicectomy	1 removal joint-mouse
5 dilatation and curettage	1 repair fracture of patella
3 hysteropexy	1 open reduction dislocation of shoulder
2 hysterectomy	1 colpoplasty
2 partial thyroidectomy	1 partial excision of omentum
2 partial phlebectomy for varicocele	1 ovarian cystectomy
2 Lane plating	1 closure fecal fistula
1 femoral hernia repair	1 laminectomy
1 excision lipoma of vulva	1 craniotomy
1 excision papilloma of breast	1 Percy cautery
1 epididymectomy	1 axillary dissection
1 amputation of leg	1 gastro-enterostomy

TABLE II  
WHITE CELL COUNTS—51 CASES

Day of count	Case No.	A. O.	P. O.	1	2	3	4	5	6	7	8	9	10	11	12
1	L. S.	9,300	20,650	18,750	14,550	10,100	12,100	9,100	8,550	.....	.....	.....	.....	.....	.....
2	G. C.	9,150	20,200	16,550	11,700	11,100	8,350	8,750	8,550	.....	.....	.....	.....	.....	.....
3	J. B.	7,150	20,800	17,550	12,200	10,150	9,100	6,050	.....	.....	.....	.....	.....	.....	.....
4	*R. M.	13,400	26,600	16,550	12,800	10,350	9,700	11,550	13,200	.....	.....	.....	.....	.....	.....
5	*J. Q.	10,600	17,800	20,600	20,900	15,800	15,900	17,600	19,650	11,350	9,100	.....	11,900	.....	9,950
6	A. L.	11,450	20,050	20,050	12,400	14,000	11,350	9,550	9,500	.....	.....	.....	.....	.....	.....
7	M. L.	8,700	17,700	11,550	12,450	11,650	11,900	8,450	.....	.....	.....	.....	.....	.....	.....
8	*M. D.	8,100	9,900	7,100	7,450	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	W. H.	14,150	25,650	21,800	17,650	12,600	12,300	12,800	12,750	13,600	14,150	.....	12,000	.....	13,050
10	E. K.	14,350	21,750	35,700	14,200	11,100	9,200	7,400	.....	.....	.....	.....	.....	.....	.....
11	*M. A.	19,400	28,950	27,450	29,600	20,000	21,900	19,750	18,550	15,400	.....	.....	.....	.....	.....
12	A. T.	11,150	21,350	15,000	16,800	8,300	8,800	.....	.....	.....	.....	.....	.....	.....	.....
13	H. S.	9,900	27,750	16,200	17,550	12,250	10,700	12,700	10,150	7,300	.....	.....	.....	.....	.....
14	*H. E.	8,800	29,050	14,800	15,050	9,050	9,650	10,400	15,800	11,100	14,000	13,000	.....	8,800	.....
15	E. D.	11,550	18,350	13,500	11,350	15,650	10,700	11,300	.....	.....	.....	.....	.....	.....	.....
16	H. S.	9,050	19,000	15,000	11,350	9,550	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	A. F.	6,250	18,100	9,050	9,800	8,500	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	*J. D.	12,550	15,050	13,350	10,000	8,250	8,400	.....	.....	.....	.....	.....	.....	.....	.....
19	*W. P.	13,950	23,200	19,800	16,250	9,950	7,150	.....	.....	.....	.....	.....	.....	.....	.....
20	*I. G.	9,300	15,700	16,500	15,350	15,200	16,000	11,700	11,650	16,350	.....	.....	.....	.....	.....
21	*H. O.	9,500	21,000	11,750	9,600	6,700	5,600	.....	.....	.....	.....	.....	.....	.....	.....
22	A. N.	6,000	20,800	17,400	13,500	11,000	12,050	10,100	9,600	9,300	9,100	7,250	.....	.....	.....
23	S. L.	8,250	17,100	11,000	11,350	9,050	11,400	10,400	14,250	9,400	.....	.....	.....	.....	.....
24	A. S.	10,300	33,050	17,700	16,600	13,400	12,400	10,450	10,250	10,650	.....	.....	.....	10,950	.....
25	*M. K.	10,500	14,600	11,950	11,600	7,450	8,200	7,950	8,050	.....	.....	.....	.....	.....	.....
26	L. Z.	9,100	16,600	10,200	10,800	8,500	5,900	.....	.....	.....	.....	.....	.....	.....	.....
27	R. B.	9,250	30,000	16,950	14,700	9,900	11,000	11,800	8,600	8,300	.....	.....	.....	.....	.....
28	E. K.	12,150	13,100	12,250	11,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	H. S.	9,000	16,950	13,300	10,150	7,950	7,400	.....	.....	.....	.....	.....	.....	.....	.....
30	*N. N.	13,600	18,050	22,700	15,800	13,550	10,700	10,800	12,150	10,800	14,600	12,200	8,600	.....	.....
31	B. W.	6,450	14,200	9,850	7,300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
32	G. S.	8,000	14,750	10,700	10,200	10,100	8,000	.....	.....	.....	.....	.....	.....	.....	.....
33	F. S.	7,100	14,000	8,900	9,200	8,050	.....	.....	.....	.....	.....	.....	.....	.....	.....
34	E. M.	8,150	20,600	12,850	12,500	11,600	8,300	8,750	.....	.....	.....	.....	.....	.....	.....

# BLOOD COUNTS IN NON-INFECTIVE CONDITIONS

35	M. E.	.....	13,050	32,750	20,400	15,950	13,250	10,150	11,700	14,050	10,700	11,650	12,750	.....	.....
36	†J. B.	.....	6,350	17,300	.....	10,800	6,500	.....	.....	.....	.....	.....	.....	.....	.....
37	H. M.	.....	11,250	17,300	12,550	6,700	.....	.....	.....	.....	.....	.....	.....	.....	.....
38	H. C.	.....	12,200	37,100	21,150	16,050	17,300	13,600	16,700	15,500	10,000	10,400	11,850	.....	.....
39	*C. N.	.....	12,450	19,500	16,250	12,600	16,700	11,000	8,350	.....	.....	.....	.....	.....	.....
40	L. G.	.....	11,900	15,100	13,900	12,200	17,700	13,350	10,050	.....	.....	.....	.....	.....	.....
41	*J. S.	.....	13,100	32,600	19,000	20,100	16,400	12,000	.....	12,700	12,550	12,500	.....	.....	.....
42	J. R.	.....	10,100	21,150	19,800	12,000	10,200	10,650	.....	12,950	8,500	.....	.....	.....	.....
43	M. K.	.....	11,300	22,500	21,650	16,650	.....	9,800	8,200	.....	.....	.....	.....	.....	.....
44	†B. A.	.....	8,800	17,300	13,000	.....	12,200	14,500	12,250	12,250	10,800	12,250	14,250	11,700	8,400
45	I. S.	.....	10,550	24,950	20,000	14,400	13,000	11,000	8,900	7,400	.....	.....	.....	.....	.....
46	†A. S.	.....	9,600	15,950	12,900	10,900	11,450	13,600	9,150	8,050	.....	.....	.....	.....	.....
47	H. N.	.....	8,900	26,300	16,300	17,050	10,900	9,300	7,850	.....	.....	.....	.....	.....	.....
48	†B. Z.	.....	9,600	19,050	16,650	12,500	11,600	.....	.....	.....	.....	.....	.....	.....	.....
49	J. B.	.....	6,300	17,050	11,350	11,700	7,900	.....	.....	.....	.....	.....	.....	.....	.....
50	A. E.	.....	10,250	27,400	17,450	16,400	11,800	9,650	10,000	10,200	11,400	10,900	.....	.....	.....
51	M. A.	.....	10,250	25,250	17,650	15,700	12,450	12,300	10,350	10,550	.....	.....	.....	.....	.....

\* Large hernia.

† Infected.

‡ Carcinoma of the uterus with degeneration.

number of cases which have some one thing in common, that this highest common factor, so to speak, can stand out prominently and the individual variations be reduced to a minimum.

*Plan.*—With the purpose of finding out the extent of post-operative leucocytosis in man and at the same time arriving, if possible, at some conclusions regarding the prime factors in its production, 51 cases were studied in the wards of the Presbyterian Hospital. These cases were chosen at random, the only cases not accepted in the series being those in which an acute infection was present before operation or a marked infection expected after it. A glance at Table I will reveal the diversity of the cases studied.

In planning the study, I tried to consider all of the factors which might have a bearing on the subject, in the periods before, during, and after operation. In each case the following data were obtained—the age, sex, and type of individual; the character, length and severity of the operation; the degree of trauma to the tissues and the number of foreign bodies introduced; the estimated blood and other body fluids lost by sweating and vomiting (in some cases also the fluid intake and urinary output); the method and kind of anæsthetic and the length of anæsthesia; and the general condition of the patient as indicated by appearance, respiration and pulse during the anæsthetic. In the post-operative course of the patient, notes were made on the condition of the wound found at dressings. Also the maximum and minimum temperatures for each day were charted as long as the blood counting was continued. Individual charts were made and curves plotted for the total white and red cell counts and the per cent. of polynuclears.

An ante-operative (A. O.) count was made on the afternoon before the morning operation (in a very few cases just before operation). A second count was made on the afternoon of the day of operation, approximately six hours post operation (P. O.). Another count was made every afternoon following until it returned either to normal or to the initial count. In making averages, those cases which fell to normal before the twelfth day were considered to maintain their final count until that day.

In all of the 51 cases a daily white cell count was made. In 39 a daily differential count was made. In 26 the red cells were counted A. O. and P. O., and on alternate days thereafter.

Although individual charts were made, I have not attempted to draw conclusions from any one case, but I have so grouped the cases according to the common factors, that certain very significant points are brought out.

*Findings.*—In every single case the white count rose six hours after operation—in 2 cases slightly, in 6 cases to an extreme degree, but in the large majority, quite uniformly doubling itself. Tables II, III and IV give the complete results.

The careful observation of the condition of the wounds at dressings revealed slight infection of the wound in 7 cases and moderate infection in 2 cases—positive cultures being obtained in 6 cases. These 9 cases have been set aside because of the frank presence of a generally accepted leucocyte stimulant. The other 42 cases have been studied both as a whole and divided

# BLOOD COUNTS IN NON-INFECTIVE CONDITIONS

TABLE III  
RED CELL COUNTS—26 CASES

Day of count	A. O.	P. O.	2	4	6	8	10	12
Case No.								
14	4,660,000	4,820,000	3,020,000	3,110,000	.....	.....	.....	.....
15	4,770,000	4,930,000	4,760,000	4,040,000	.....	.....	.....	.....
16	5,040,000	4,770,000	4,500,000	.....	.....	.....	.....	.....
17	4,990,000	5,730,000	5,310,000	.....	.....	.....	.....	.....
18	4,990,000	4,600,000	5,080,000	4,780,000	.....	.....	.....	.....
19	4,466,000	4,840,000	4,440,000	4,550,000	.....	.....	.....	.....
20	5,400,000	4,980,000	5,270,000	5,690,000	6,740,000	.....	.....	.....
21	6,300,000	5,290,000	6,050,000	6,440,000	.....	.....	.....	.....
22	5,480,000	6,260,000	4,860,000	4,980,000	4,130,000	4,100,000	.....	.....
23	5,310,000	5,560,000	5,330,000	4,740,000	4,680,000	4,100,000	.....	.....
24	.....	5,240,000	3,720,000	4,210,000	3,950,000	3,880,000	.....	.....
25	3,070,000	3,060,000	4,280,000	3,680,000	3,620,000	.....	.....	.....
26	5,340,000	4,620,000	5,170,000	5,060,000	4,140,000	.....	.....	.....
27	5,190,000	5,990,000	5,270,000	5,110,000	.....	.....	.....	.....
28	3,940,000	4,310,000	4,860,000	.....	.....	.....	.....	.....
29	5,860,000	5,480,000	5,080,000	4,450,000	.....	.....	.....	.....
30	6,120,000	4,664,000	6,090,000	4,760,000	5,030,000	6,220,000	4,590,000	.....
31	4,070,000	4,850,000	3,650,000	.....	.....	.....	.....	.....
32	4,224,000	3,630,000	3,630,000	4,790,000	.....	.....	.....	.....
33	4,660,000	5,112,000	4,944,000	.....	.....	.....	.....	.....
34	5,240,000	5,470,000	5,380,000	5,760,000	.....	.....	.....	.....
35	5,448,000	4,344,000	4,740,000	4,424,000	4,950,000	4,330,000	4,224,000	.....
36	4,680,000	5,136,000	5,190,000	.....	.....	.....	.....	.....
37	4,290,000	4,170,000	4,640,000	.....	.....	.....	.....	.....
38	5,280,000	4,950,000	3,520,000	.....	.....	.....	.....	.....
39	5,940,000	6,300,000	5,670,000	4,176,000	4,370,000	3,056,000	3,770,000	.....

\* No explanation could be found for the wide variations in this case.

TABLE IV  
POLYMORPHONUCLEAR PERCENTAGE—39 CASES

Day of count	A. O.	P. O.	1	2	3	4	5	6	7	8	9	10	11	12
Case No.														
1	67	91	78	75	70	69	...	...	...	...	...	...	...	...
2	36	79	63	63	60	63	55	51	...	...	...	...	...	...
3	70	93	76	81	84.5	76	72	...	...	...	...	...	...	...
4	62	88	69	79	67	67	65	78	66	55	...	...	...	...
5	55	90	83	84	81	83	80	86	85	...	76	86	...	77
6	58	91	86	68	59	...	61	51	...	...	...	...	...	...
7	50	88	70	76.5	69	64	55	...	...	...	...	...	...	...
8	72	84	71	70	...	...	...	...	...	...	...	...	...	...
9	65	86	79	75	76	71	66	59	65.5	72	...	65	...	60
10	70	84	80	69	75	62	56	...	...	...	...	...	...	...
11	85	93	92	86	84	82	87	83.5	80.5	...	...	...	...	...
12	72	89	77	75	69	62	...	...	...	...	...	...	...	...
13	50	88	73	76	63	58	83	54	55	...	...	...	...	...
14	70	85.5	80.5	79	76.5	74.5	76	86	81	79	86	...	73	...
15	67	85.5	78.5	73	72	76	68	...	...	...	...	...	...	...
16	47	90	74	52	45.5	...	...	...	...	...	...	...	...	...
17	67	85.5	67	79	70	...	...	...	...	...	...	...	...	...
18	73	89	70	72.5	66	67.5	...	...	...	...	...	...	...	...
19	85.5	91	90	83.5	76.5	69.5	...	...	...	...	...	...	...	...
20	71	85	80	82.5	85.5	83.5	70	73.5	79.5	...	...	...	...	...
21	66.5	88	70.5	70.5	62.5	58	...	...	...	...	...	...	...	...
22	61	94.5	86.5	83.5	60	75.5	72	65.5	67	76	62	...	...	...
23	72	89.5	70.5	65	76	59	70.5	75.5	63	...	57	...	...	...
24	78	92	83.5	76	78	75	68	69	71.5	...	60	...	48	...
25	68.5	91	76	87	79.5	78.5	86.5	...	...	...	...	...	...	...
26	64	83.5	82	72.5	75.5	64	...	...	...	...	...	...	...	...
27	62	95.5	83.5	82	74	75	78	69.5	64.5	...	...	...	...	...
28	59	59	60	46	...	...	...	...	...	...	...	...	...	...
29	57	88.5	77.5	73	66	63	...	...	...	...	...	...	...	...
30	79	82	80.5	77.5	76.5	69.5	61.5	69	62	67	61.5	56	...	...
31	69	93	74.5	67	...	...	...	...	...	...	...	...	...	...
32	56	86	75	72.5	67.5	74	...	...	...	...	...	...	...	...
33	64	88	73	63	65	...	...	...	...	...	...	...	...	...
34	47.5	90	84	80	60.5	57.5	61.5	...	...	...	...	...	...	...
35	62	94.5	79.5	72	74	65.5	71	71	63.5	63.5	64	65	...	...
36	59.5	85.5	79	70.5	71.5	...	...	...	...	...	...	...	...	...
37	70.5	79.5	66.5	60	...	...	...	...	...	...	...	...	...	...
38	69	92.5	81.5	83	80.5	75	77	71.5	76.5	66	79	68.5	...	...
39	67.5	89	79	81.5	73	67.5	69.5	...	...	...	...	...	...	...



## BLOOD COUNTS IN NON-INFECTIVE CONDITIONS

into groups according to various classifications, in the attempt to bring out the factors in the leucocytosis.

These classifications consider (a) the sex and type of individual, (b) the kind and duration of the anæsthetic, (c) the character of the operation with respect to contamination, (d) the degree of trauma to the tissues, (e) the number of foreign bodies introduced, and (f) the blood loss. The factor of concentration of the blood, which Da Costa and Kalteyer emphasize, was considered, but was found to have in itself so many sub-factors, that it was impossible to make any satisfactory classification upon that basis. In it there had to be considered—daily fluid intake and output; ante-operative purging; sweating, temperature and humidity of the operating room, and general weather conditions affecting sweating; vomiting during and after

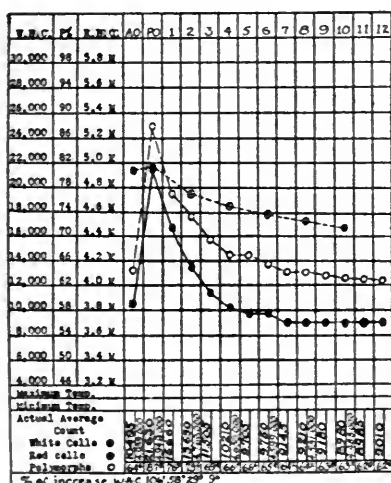


FIG. 1.—All of the 42 non-infected cases. White cell count in 42. Differential count in 33. Red cell count in 22.

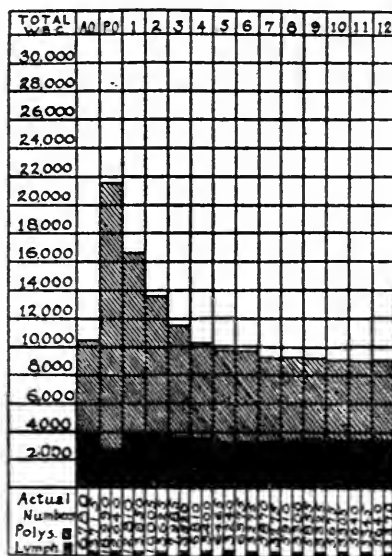


FIG. 2.—Showing that the leucocytosis is essentially a polynucleosis.

operation; post-operative colon irrigations, enemata and rectal administration of fluids. There were not two cases alike in all of these phases. Furthermore, the trivial rise in red cells (see Fig. 1) and the actual fall in lymphocytes (see Fig. 2) indicate that mere concentration of the blood is a minimal factor.

The composite curves in the 42 non-infected cases taken as a whole are shown in Fig. 1. The letters and numbers at the top indicate the days on which the counts were made. At the left are the figures representing the various levels of the count in white cells, red cells, and per cent. of polynuclears. At the bottom are the actual average figures and the per cent. of white cell increase over the initial count. The dots and solid lines represent the curve of the white cells, the circles and dash lines, the polynuclears, the wheels and dotted lines, the red cells.

In these cases it will be seen that the average A. O. blood count was as follows: White blood-cells, 10,495, polymorphonuclears, 64.6 per cent., red blood-cells, 4,939,000. Six hours P. O. it became: white blood-cells, 21,630, polymorphonuclears, 87.8 per cent., red blood-cells, 4,948,000. Thus, in six hours, the total white cells increased 106.1 per cent., the polymorphonuclears 36 per cent., and the red cells less than 0.2 per cent. On subsequent counts there was a rapid falling off of total white cells and polynuclears—the white cells falling below the initial count on the fourth day P. O. The polys fell more gradually but reached the initial count on the seventh day. The red cells fell gradually and progressively throughout the ten days P. O. with an average loss in that time of 451,000 cells per c.mm. An application of Sondern's<sup>1</sup> resistance line to this count would show a change in the direction of the line from a sharp decline to a slight rise on the first two counts with a subsequent return to the original direction.

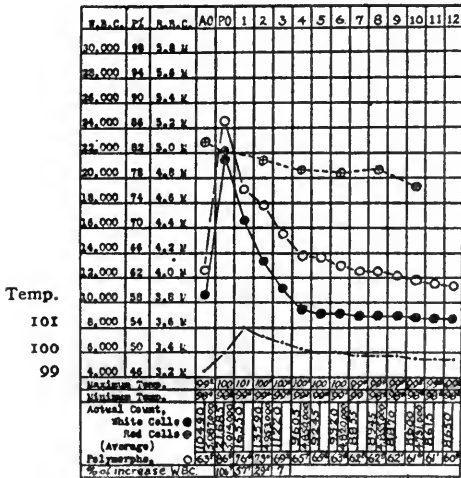


FIG. 3.—Clean cases. White cell count in 28. Differential count in 23. Red cell count in 14.

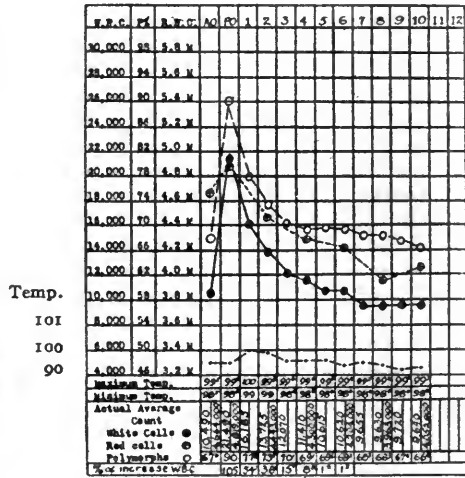


FIG. 4.—Borderline cases. White cell count in 14. Differential count in 10. Red cell count in 8.

Fig. 2 shows very plainly that the response is due entirely to the polymorphonuclear leucocytes, for the total number of these cells rapidly increases while the actual number of lymphocytes remains practically constant.

In order to determine the influence of infection and contamination, the 42 non-infected cases have been divided into clean cases, of which there were 28, and borderline cases, of which there were 14. Clean cases are considered to be those in which the operation from beginning to end is kept sterile, with no contamination of the operative field. Borderline cases are those in which a certain amount of contamination of the field is expected, such as occurs, for instance, in operations on the female genital tract or on the gastro-intestinal tract and its appendages (with the exception of the vermiform appendix operation which is clean). The composite curves for this division are shown in Figs. 3 and 4. With these curves, the reader

## BLOOD COUNTS IN NON-INFECTIVE CONDITIONS

should compare Fig. 5 which gives the results in the 9 infected cases. On these three charts the composite temperature curves are also plotted. The uniformity with which the white count rises in these three groups is most striking. In the clean group the six-hour P. O. rise is 106.7 per cent. over the initial count. In the borderline cases it is 105 per cent. In the infected cases it is 105 per cent. This seems to indicate that infection or contamination has nothing whatever to do with the initial rise. The influence is seen, however, in the later days. In the clean cases the count returns to normal on the fourth day; in the borderline cases on the seventh day; in the infected cases not until the twelfth day. Infection, therefore, although it is not responsible for the rise, does delay the fall—the effect beginning on the second or third day P. O.

The temperature curves on these charts show that the rise in tempera-

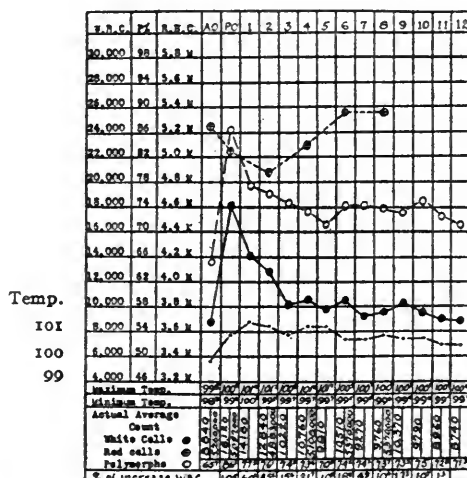


FIG. 5.—Infected cases. White cell count in 9. Differential count in 6. Red cell count in 4.

ture P. O. does not correspond, in time, to the rise in white cells, but is a later phenomenon of the post-operative reaction.

An interesting observation with respect to the infected cases is that in three of them *Staphylococcus albus* was recovered, and in all three the count fell to normal with the same rapidity that it did in the clean cases. With one exception, where other organisms were present, and in those cases in which positive cultures were not obtained (possibly anaërobic organisms were present) the count remained high.

Table V shows the cases grouped according to sex. Here it is seen that in 15 males the white cells increased 100.4 per cent. over the initial count, while in 27 females the rise was 108.7 per cent. Here there is a difference of only 8.3 per cent. The count in the male cases falls to normal one day before the count in the female cases. Apparently the factor of sex is unimportant.

TABLE V  
CLASSIFICATION ACCORDING TO SEX

	Male, 15				Female, 27			
	White blood-cells	Per cent. of increase	Polymorpho-nuclears, per cent.	Red blood-cells	White blood-cells	Per cent. of increase	Polymorpho-nuclears, per cent.	Red blood-cells
A. O.	10,590	.....	64.1	5,241,000	10,380	.....	64.9	4,753,000
P. O.	21,475	100.4	86.9	4,983,000	21,600	108.7	88.4	4,932,000
1	16,135	50.9	75.6	.....	16,690	60.8	77.7	.....
2	13,865	27.8	75.8	5,059,000	13,640	31.4	72.1	4,604,000
3	11,265	5.4	70.9	.....	11,700	12.7	68.5	.....
4	9,220	.....	67.8	4,835,000	10,750	3.6	65.9	4,551,000
5	9,080	.....	67.2	.....	10,090	.....	64.9	.....
6	9,160	.....	66.5	4,865,000	10,090	.....	63.5	4,445,000
7	8,795	.....	65.7	.....	9,340	.....	63.5	.....
8	8,935	.....	66.3	5,016,000	9,370	.....	62.5	4,280,000
9	8,795	.....	65.9	.....	9,410	.....	62.1	.....
10	8,385	.....	65	4,812,000	9,300	.....	61.5	4,323,000
11	8,385	.....	65	.....	.....	.....	.....	.....
12	8,390	.....	64.6	.....	.....	.....	.....	.....

# BLOOD COUNTS IN NON-INFECTIVE CONDITIONS

TABLE VI  
CLASSIFICATION ACCORDING TO TYPE OF INDIVIDUAL

	Average 20			Obese 14			Neurotic 5		Asthenic 3	
	White blood-cells	Per cent. of increase	Poly-morphonuclears, per cent.	Red blood-cells	White blood-cells	Per cent. of increase	Poly-morphonuclears, per cent.	Red blood-cells	White blood-cells	Per cent. of increase
A. O.	10,635	.....	63.9	5,043,000	10,500	.....	63.9	5,099,000	10,900	.....
P. O.	22,725	113.7	90	5,235,000	21,505	104.8	86.2	4,708,000	18,380	68.7
1	16,165	52	77.7	.....	15,570	48.3	74.8	.....	19,620	80
2	13,615	28	73.6	4,735,000	13,200	25.7	73	4,855,000	12,580	15.4
3	11,640	9.4	69.7	.....	11,010	4.9	69	.....	12,200	12
4	10,300	.....	66.9	4,560,000	9,185	.....	65.5	4,826,000	10,250	.....
5	9,575	.....	67.1	.....	9,345	.....	66.1	.....	9,980	.....
6	9,360	.....	63.9	4,496,000	9,745	.....	67.5	4,889,000	10,130	.....
7	9,090	.....	63.8	.....	8,865	.....	65.2	.....	9,180	.....
8	9,160	.....	64.2	4,434,000	8,970	.....	63	4,801,000	9,140	.....
9	9,215	.....	63.5	.....	8,935	.....	63.8	.....	8,760	.....
10	9,025	.....	63.2	4,424,000	8,770	.....	62.4	4,686,000	8,760	.....
11	9,035	.....	62.5	.....	.....	.....	.....	.....	.....	.....
12	9,090	.....	62.2	.....	.....	.....	.....	.....	.....	.....

The classification according to the type of the individual divides the cases roughly into four groups: Average (20), obese (14), neurotic (5), and asthenic (3). These groups are shown in Table VI. We see by this group that the so-called average cases rise to 113.7 per cent. over the initial count. The obese cases rise to 104.8 per cent. The neurotic cases to 68.7 per cent. on the second count and 80 per cent. on the third. The three asthenic cases increased only 67.4 per cent. In the last two groups there are, of course, too few cases from which to draw definite conclusions, but apparently the factor of type of individual is important.

Figs. 6 and 7 show the curves in 24 ether cases and 18 gas and oxygen cases, respectively. The difference here is striking. In the ether cases the P. O. rise is 121.9 per cent. of the initial count with a return to normal on the fifth day. In the gas and oxygen cases the rise is only 85.1 per cent., and the return is on the fourth day. There is a difference here of 36.8

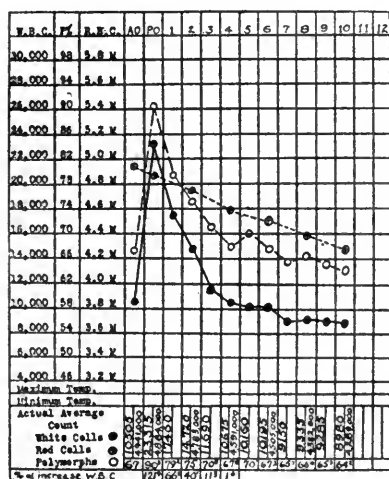


FIG. 6.—Ether cases. White cell count in 24. Differential count in 16. Red cell count in 11.

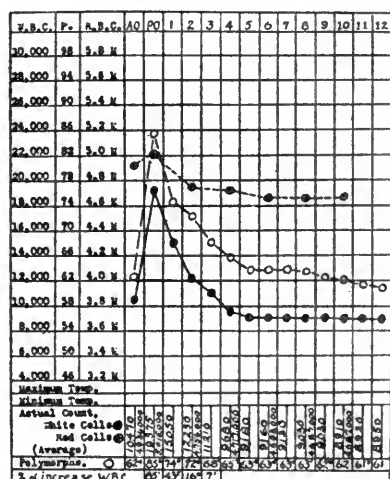


FIG. 7.—Gas and oxygen cases. White cell count in 18. Differential count in 17. Red cell count in 11.

per cent. The red cell curves on these two charts show a much greater post-operative fall in the ether cases than in the gas and oxygen cases. In this series, there was no special selection of cases for either gas-oxygen, or ether. Long and short, severe and easy cases were performed under both ether and gas-oxygen. In most of the gas-oxygen cases a small amount of ether was used, from 3j to 3ij.

The average duration of anæsthetic administration was found to be one hour and ten minutes. The cases were accordingly divided at this point into long-anæsthetic cases and short-anæsthetic cases. Table VII contrasts 19 long-anæsthetic cases where the increase is 114.4 per cent. and the return on the fourth day, with 23 short-anæsthetic cases where the count increased 97.9 per cent. and returned on the fourth day. The difference here is 16.5 per cent.—not striking but nevertheless real. It should be remembered that a much larger amount of anæsthetic is required

# BLOOD COUNTS IN NON-INFECTIVE CONDITIONS

TABLE VII  
CLASSIFICATION ACCORDING TO DURATION OF ANESTHESIA

	Short, 23				Long, 19			
	White blood-cells	Per cent. of increase	Polymorpho-nuclears, per cent.	Red blood-cells	White blood-cells	Per cent. of increase	Polymorpho-nuclears, per cent.	Red blood-cells
A. O.	9,885	....	61.7	4,782,000	11,225	.....	68.5	5,253,000
P. O.	19,565	97.9	81.5	4,871,000	24,080	114.5	89.2	5,077,000
1	14,610	47.8	74.8	.....	18,630	65.9	79.7	.....
2	12,085	22.3	71.4	4,796,000	15,495	38	76.7	4,720,000
3	10,865	9.9	67.7	.....	12,280	9.4	71.1	.....
4	9,535	....	64.5	4,657,000	11,025	.....	69.1	4,649,000
5	9,045	....	65.4	.....	10,505	.....	68.4	.....
6	9,000	....	64.8	4,579,000	10,665	.....	66.4	4,635,000
7	8,565	....	63.2	.....	9,840	.....	66.3	.....
8	8,465	....	62.6	4,538,000	10,105	.....	66.9	4,528,000
9	8,490	....	62.3	.....	10,015	.....	65.7	.....
10	8,490	....	62.3	4,538,000	9,570	.....	64.2	4,401,000
11	.....	....	....	.....	9,590	.....	63.3	.....
12	.....	....	....	.....	9,640	.....	63	.....

for the induction than for the last stages of anaesthesia, and perhaps the amount is a much more important factor than the mere duration, but this is difficult to measure, especially in the gas and oxygen cases. The difference in the red cell curves is more striking than the changes in the white cells—the red count falling much more rapidly in the cases with long anaesthesia.

The results in the classification according to the degree of trauma to the tissues are shown in Figs. 8 and 9. Trauma was considered to consist of cutting, tearing, and handling the tissues. Twenty-five cases were subjected to marked trauma and in these the rise was 114 per cent. over the initial count. Seventeen cases had only slight trauma and the rise was only 90.7 per cent. The difference between these is 23.7 per cent. In both, the

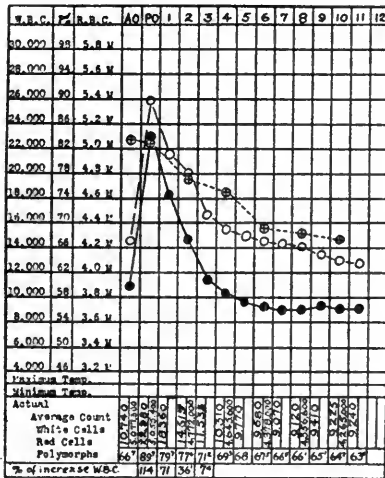


FIG. 8.—Cases receiving marked trauma. White cell count in 25. Differential count in 19. Red cell count in 10.

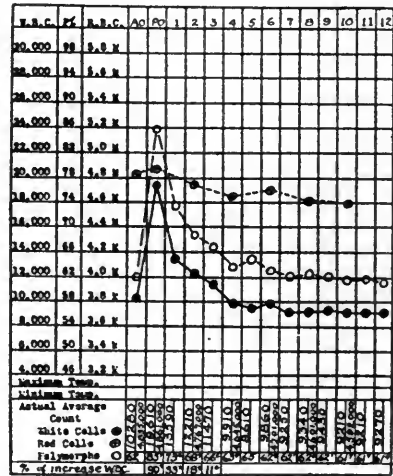


FIG. 9.—Cases undergoing slight trauma. White cell count in 17. Differential count in 15. Red cell count in 12.

count returned to normal on the fourth day. Here also the progressive anaemia is more pronounced in the cases with increased trauma than in those with slight trauma.

The cases were also divided into two groups according to the number of foreign bodies left in the tissues. At the time of operation every stitch and ligature was counted. In this summary no differentiation is made between the various materials used. Each stitch and ligature was counted as 1 and in the four cases in which drainage for bleeding was necessary, each drain was counted arbitrarily as 5. The average was 40. Fig. 10 shows 19 cases which had more than 40 foreign bodies left in. The rise here is 119 per cent. over the initial count. Fig. 11 shows the composite curves in 23 cases in which less than 40 foreign bodies were introduced. The rise in these cases is 96.3 per cent., and the difference between the two groups is 22.7 per cent. The stimulating effect of suture material, however, does not seem to be of long duration, since those cases with many foreign bodies



## BLOOD COUNTS IN NON-INFECTIVE CONDITIONS

return to normal before those with few. The fall in red cells is practically the same in these two groups.

The last grouping is according to the blood loss. In only one case was there any large amount of blood lost (9 ounces). The smallest amount was 1 drachm. The average was found to be 2 ounces. The 22 cases in which more than that amount was lost are shown in Fig. 12. Here the initial rise is seen to be 119.7 per cent., falling on the fifth day. In 20 cases losing less than 2 ounces (Fig. 13) the rise is 90.3 per cent., falling on the fourth day. The difference is 29.4 per cent.

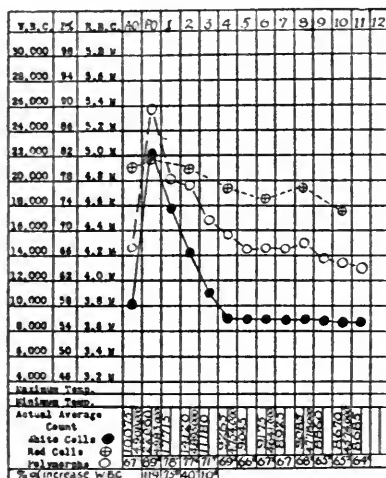


FIG. 10.—Cases retaining more than forty foreign bodies. White cell count in 19. Differential count in 12. Red cell count in 8.

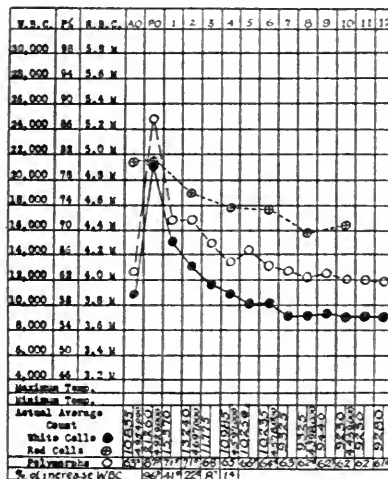


FIG. 11.—Cases retaining less than forty foreign bodies. White cell count in 23. Differential count in 21. Red cell count in 14.

### DISCUSSION

From the first five charts certain facts are available. From the others only inferences may be drawn. It is a fairly generally accepted theory that the outpouring of leucocytes is a reaction to injury. If that theory be true, there are two variable factors—first, the kind or degree of injury; second, the resistance or vigor of the reacting individual. Up to a certain point the greater the injury and the greater the resistance of the individual, the greater will be the reaction. The foregoing charts indicate that an operation performed under an anæsthetic is sufficient injury to cause a marked increase in the white cell count. Severe trauma to the tissues and organs, introduction of a large number of foreign bodies, long anæsthesias, especially with ether, and much loss of blood, cause the greatest reactions and may be considered to be the severest injuries. All of these factors are more or less under the control of the operating surgeon. The resistance of the patient is not so easily controlled, but it must be considered as an active factor in the variation in the count. If the above observations be true, it is obvious that any case having all of the above leucocyte stimulating factors ought to have a very high count. On the other hand, any case

having none of these factors ought to have a very low count. There are just three cases in this series which represent these extremes and their charts bear out the points just made. The curves of two of these are shown in Figs. 14 and 15. The first case is an average female with long ether anæsthesia, increased trauma, many stitches, and much loss of blood. The second case is an obese male with a short gas and oxygen anæsthesia, slight trauma, few stitches, and small loss of blood.

The third case, in which only the white cells were counted, shows this even more strikingly—L. A., an average female—ether anæsthesia for one

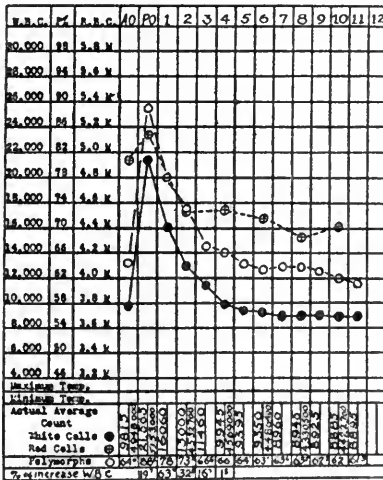


FIG. 12.—Cases losing more than two ounces of blood. White cell count in 22. Differential count in 15. Red cell count in 11.

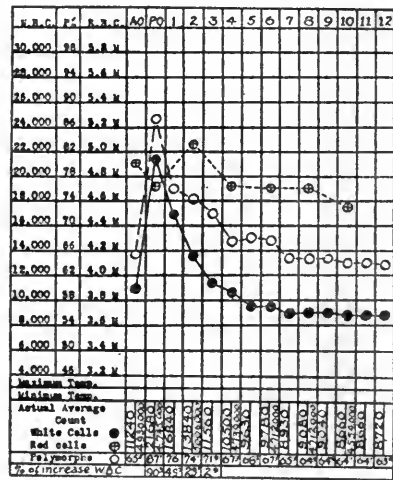


FIG. 13.—Cases losing less than two ounces of blood. White cell count in 20. Differential count in 18. Red cell count in 11.

hour and twenty-eight minutes, marked trauma, 62 foreign bodies introduced, blood loss, 4 ounces. The count follows:

	White blood-cells	Per cent. of increase
A.O.	10,250	....
P.O.	25,250	146.3
1	17,650	72.2
2	15,700	53.1
3	12,450	21.5
4	12,300	20
5	10,350	1
6	10,550	1

The absolute control of every factor mentioned above is impossible either with human beings or with experimental animals. Some attempt has been made to control certain of them, however.

1. The variation between the sexes with respect to the blood reaction to injury has never been carefully observed. The slight difference in the reaction given by the two sexes in this series may be accidental, or it may be due

## BLOOD COUNTS IN NON-INFECTIVE CONDITIONS

to the fact that the average female ward patient is generally in relatively better physical condition than the average male ward patient.

2. It has frequently been found in acute infective conditions that a weak individual gives a weak leucocytic response to the infection. Likewise, in non-infective conditions, apparently, the "average" patient, who is obviously more healthy than the obese, the neurotic, or the asthenic, is more capable of giving a strong reaction. An interesting observation was made in one of my cases—a very neurotic individual. The evening before the day scheduled for operation, she became almost panic stricken with fear and in the morning refused operation. The count went up from 12,200 to 17,400 without operation. This was considered at the time to be a neurotic manifestation, but Table V seems to show that nervousness is not a leucocytic

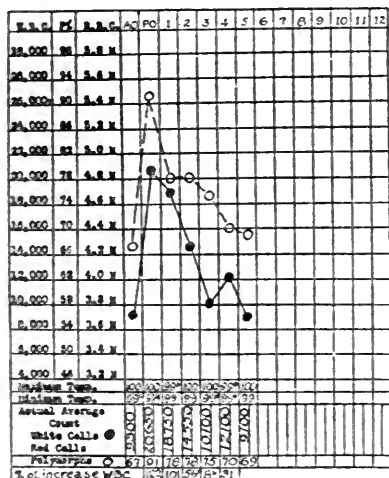


FIG. 14.—Case showing all of the leucocyte stimulating factors. Average female; ether, one hour twenty minutes; marked trauma; foreign bodies, forty-eight; blood loss, three ounces.

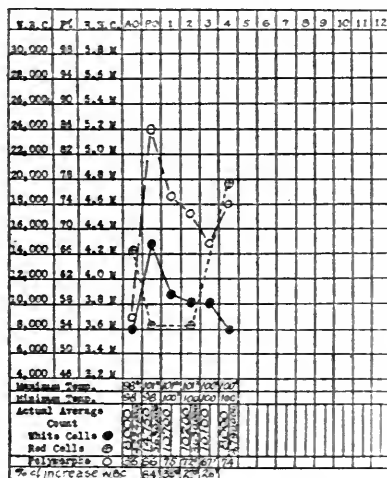


FIG. 15.—Case showing a minimum number of leucocyte stimulating factors. Obese male; gas and oxygen, one hour nine minutes; slight trauma; foreign bodies, twenty-nine; blood loss, three drachms.

stimulant. One of the other neurotic cases was one of the two cases to have only a slight post-operative rise (Case 28).

3. Mann<sup>8</sup> has shown that where anæsthesia in dogs is kept up continuously for three or four hours, there is a doubling of the count at the end of four hours. Krumbaar<sup>9</sup> likewise showed that anæsthesia in dogs causes a leucocytosis. Chadbourne<sup>5</sup> found this increase to be most marked in the early stages of anæsthesia. I counted one case in the hospital which seems to bear out this observation. Unfortunately, no ante-operative count was made. The first count was made three minutes after anæsthesia had started. Thereafter a count was made every fifteen minutes throughout a two-hour operation. The case was a very difficult double hernia with balls of omentum down in the scrotum. (Incidentally I may say that large herniæ frequently give counts between 10,000 and 15,000 A. O.) This count follows:

# FRANK L. MELENEY

3 minutes, white blood cells .....	18,450	Polymorphonuclears, 74	per cent.
18 minutes, white blood cells .....	23,500	Polymorphonuclears, 64	per cent.
33 minutes, white blood cells .....	27,950	Polymorphonuclears, 61	per cent.
48 minutes, white blood cells .....	27,750	Polymorphonuclears, 62	per cent.
63 minutes, white blood cells .....	29,450	Polymorphonuclears, 69½	per cent.
78 minutes, white blood cells .....	26,750	Polymorphonuclears, 68	per cent.
93 minutes, white blood cells.. .....	29,450	Polymorphonuclears, 62½	per cent.
108 minutes, white blood cells .....	29,750	Polymorphonuclears, ....	per cent.
After 6 hours, white blood cells .....	32,800	Polymorphonuclears, 90½	per cent.
First day P.O., white blood cells .....	22,350	Polymorphonuclears, 86½	per cent.
Second day P.O., white blood cells .....	16,550	Polymorphonuclears, 84½	per cent.
Third day P.O., white blood cells .....	13,550	Polymorphonuclears, 72	per cent.
Fourth day P.O., white blood cells .....	9,700	Polymorphonuclears, 73	per cent.
Fifth day P.O., white blood cells .....	9,700	Polymorphonuclears, 69	per cent.

I have no explanation to offer for the fact that in this case the polymorphonuclears made a later rise than the total white cells.

Cabot, Blake and Hubbard<sup>7</sup> studied the effect of both anæsthetic and operation by counting the blood just before anæsthesia, again just before the operation, and a third time just after the operation. They found practically no rise in the second count, but in half of the cases the count immediately after operation was increased. Thus their study of the effect of the anæsthetic covered only ten to twenty minutes time, and no account was taken of the possible late effect of either anæsthetic or operation. It would be difficult in human beings to obtain a large series of cases in which an anæsthetic was given without some kind of an operation following it. I counted one case in which a closed reduction of the shoulder was attempted under ether. Here there was some trauma to the tissues but no introduction of foreign bodies and no loss of blood. The anæsthetic lasted twenty minutes. The leucocytes ran as follows:

Just before anæsthesia, white blood cells.....	6,300
Just after operation, white blood cells.....	6,300
Six hours P.O., white blood cells.....	13,200
First day P.O., white blood cells .....	11,800
Second day P.O., white blood cells .....	8,300
Third day P.O., white blood cells.....	10,400
Fourth day P.O., white blood cells.....	8,300

It is somewhat easier to control the factor of anæsthesia by exclusion, *i.e.*, by counting a series of cases performed under local anæsthesia. This I did in four cases with the following results:

1. A.O., white blood cells.....	7,600	Polymorphonuclears, 40	per cent.
P.O. (8 hrs.), white blood cells..	14,450	Polymorphonuclears, 79	per cent.
2. A.O., white blood cells .....	8,400	Polymorphonuclears, 63	per cent.
P.O. (8 hrs.), white blood cells..	14,800	Polymorphonuclears, 73	per cent.
3. A.O., white blood cells .....	8,000	Polymorphonuclears, 54	per cent.
P.O. (14 hrs.), white blood cells.	12,350	Polymorphonuclears, 74	per cent.
4. A.O., white blood cells .....	9,700	Polymorphonuclears, 61	per cent.
P.O. (6 hrs.), white blood cells..	12,000	Polymorphonuclears, 81	per cent.

## BLOOD COUNTS IN NON-INFECTIVE CONDITIONS

Cases 1 and 2 were herniæ. Cases 3 and 4 were varicoceles. Of course, these cases are relatively simple and are in no sense representative operations with respect to trauma, foreign body introduction or blood loss, nevertheless, the counts show that the operation itself is a definite leucocytic stimulant, even if it is not the only one.

4. The factors of trauma and foreign body introduction cannot be controlled in human beings separately, and ordinarily they are complicated by the factors of anæsthesia and blood loss. Furthermore it is not practical to attempt to show the importance of one or another form of suture material used in operations on human beings, since, in practically every case, all forms are introduced. Lampé<sup>4</sup> showed in a few cases in dogs that iodized catgut produced a higher leucocytosis than silk, when used in operations.

5. The factor of blood loss has been studied by Krumbaar,<sup>9</sup> who has recently shown that the removal of 75 to 100 c.c. of blood produces a leucocytosis in dogs, even when no anæsthetic has been given. If this be true in human beings, for relatively small amounts, as Figs. 12 and 13 seem to indicate, the loss of large amounts of blood does not seem to have a corresponding effect. I made counts on three donors for transfusion. Five hundred c.c. of blood was taken from each one without anæsthetic. Although no definite conclusions can be drawn from only three cases, I introduce their counts here, considering them to be interesting observations in this connection.

	First case	Second case	Third case
Just before phlebotomy, white blood cells.....	6,200	8,200	10,800
Just after phlebotomy, white blood cells.....	8,900	7,500	9,000
About 6 hours after phlebotomy, white blood cells.....	7,900	6,400	7,700
About 30 hours after phlebotomy, white blood cells.....	.....	.....	8,600

It is conceivable that where small losses of blood, up to a certain point, would stimulate leucocytosis, large amounts are too great to be more than just compensated for by the hæmatopoietic activity of the body.

### CONCLUSIONS

1. In surgical cases undergoing operation without infection, the white cells increase in number, and about six hours after operation have more than doubled.

2. The response is due almost entirely to the outpouring of polymorphonuclear cells.

3. There is a trivial rise in red cells after operation, but in the subsequent ten days this is followed by a progressive anæmia with an average loss of about one-half million cells per c.mm.

4. The white cell count may be expected to fall rapidly in clean cases and reach normal on the fourth day. In infected or contaminated cases it will fall much more slowly.

5. Infection and contamination have nothing to do with the initial rise, but on the second or third day after operation they will tend to keep the count high.

6. Other things being equal, the count will be higher in those cases in which there are severe trauma to the tissues, many sutures and ligatures used, considerable loss of blood and long anæsthesia, especially with ether.

7. Normal individuals will produce a higher leucocytosis than abnormal types.

I wish to express my sincere thanks to Dr. Guy A. Caldwell for helping me plan this study and for counting foreign bodies introduced at operation.

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## ELECTRIC BURN CAUSING NECROSIS OF THE SKULL

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ABOUT 500 persons are killed each year in the United States by lightning. It is difficult to estimate the number of shocks or burns sustained by those working in electrical plants or in wiring, for the accidents are not reported when recovery occurs. The number of fatal accidents is undoubtedly small, but is on the increase, as is indicated by various statistics dealing with this subject. The statistics published by Langer show that there were 58 fatal electrical accidents in Germany in 1908, 139 in 1910, and 183 in 1912.

The case about to be reported presents some interesting features. The patient recovered from a very severe shock, having come in contact with a live wire carrying an alternating current of 13,200 volts with an amperage of 150. He sustained an injury to the skull which corresponds to a certain definite type of which 13 have been reported. Some eight weeks after the accident a double cataract developed rather rapidly.

Mr. C. G., age 27, referred by Dr. T. B. Smith, of Clifton, Arizona, while working at his trade on a corrugated tin roof came in contact by his head with a live wire carrying an alternating current of 13,200 volts. He was immediately knocked unconscious. It is not known how long he remained unconscious, but it is estimated that it was probably fifteen minutes after he was shocked before his friends reached him. At this time he was just beginning to move. The patient became irrational and violent when he came to, and it required three or four men to restrain him. Six hours after the accident he became rational. He suffered no particular pain at this time, but was unable to find a comfortable position. The face was so swollen that the eyes could not be opened. No special pain was noted in the areas about the head and face which had been most severely burned.

The physician who examined him shortly after the shock stated that the scalp over the junction of sagittal and coronal suture had been burned away, leaving exposed a part of the parietal and frontal bones measuring 4 in. in diameter. A burn of the forehead on the right side and one over the right parotid gland were noted. This latter burn had extended deep enough to destroy the fibres of the facial nerve passing through the gland. The gland substance was also partially destroyed, as the patient had a salivary fistula. Stenson's duct was apparently intact. The skin surrounding the areas which were burned was charred, but gradually the charred skin sloughed away. Sloughing was complete in about three weeks.

The feet were severely damaged by the electric shock. Above the right ankle, anteriorly, the skin was badly charred, as is shown in Fig. 4, and the skin over the dorsum of the right foot was torn longitudinally and burned. All the toes with the exception of the little one

were so badly torn and burned that they either dropped off or were removed.

A circular burn occurred upon the left leg above the ankle which corresponds in position to the level at which the shoe top came in contact with the skin. This burn extended down to the bone, destroying all the tendons above the ankle and dividing posteriorly the tendo Achillis. The electric current had apparently passed down the upper and outer side of the foot, lacerating and burning the skin on the dorsum of the foot and destroying the little toe.

Sloughing of the charred skin occurred much more quickly in this case than in cases resembling it which have been reported. Separation of the skin was completed in three weeks. Granulation tissue then developed rapidly and normally.

Almost eight weeks after the accident slight blurring of the vision of the left eye was noticed. The blurring lasted for two days and then the eye became hypersensitive to light for one and one-half days. The blurring of vision became progressively worse after this until vision was completely lost. The same change then occurred in the right eye, beginning February 6, 1917. When the patient entered the hospital February 21, 1917, he had a well developed bilateral cataract.

When examined upon admission to the hospital February 21, 1917, a large area of exposed necrotic bone involving both the parietal and frontal bones was found. The soft tissues surrounding the necrotic bone were in good condition. The necrotic bone was somewhat loose, but at this time was not loose enough to indicate an attempt at removal. The sequestrum shown in Fig. 1 finally became so loose that on April 12, 1917, it could be easily removed with tissue forceps. The sequestrum contains a part of the sagittal and coronal sutures at the point of meeting and the parts of the parietal and frontal bone adjoining these. It includes both plates. The dura which was exposed when the sequestrum was removed was covered with healthy granulation tissue. This granulating surface was grafted on the day following removal of the sequestrum with Thiersch grafts.

The granulating surface over the parotid gland was moist, a small salivary fistula having formed as a result of the burn extending into the gland substance. The fibres of the facial nerve were apparently destroyed by this burn for there is a complete facial palsy on the right side. This surface was also covered with Thiersch grafts. The discharge of saliva gradually ceased. The granulating surface has gradually healed, most of the skin grafts having taken.

At the time these granulating surfaces were grafted, a pedunculated graft was turned down from the side of the left leg to cover the granulating surface above the ankle in order to prevent the contraction of a circular scar, as an oedema of the foot was fast developing, and there was marked interference with the circulation of the foot. A considerable amount of fat was taken with this graft, as subsequently an attempt may be made to repair the destroyed tendons by the transplantation of fascial strips.

There are no changes in the respiratory, digestive, vascular or



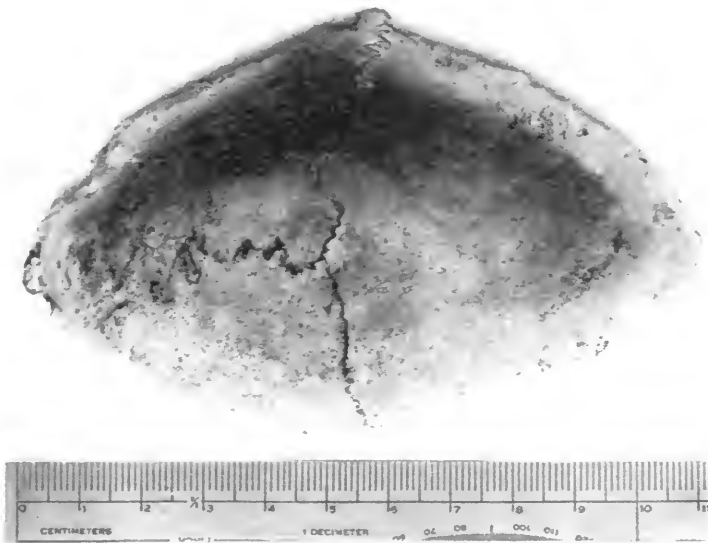


FIG. 1.—Sequestrum of parts of the parietal and frontal bones, including both tables, which was removed eighteen weeks after the accident. The sequestrum was so loose by this time that it could be removed with tissue forceps. The underlying dura was covered with healthy granulation tissue. The superior longitudinal sinus was intact.



FIG. 2.—Size of defect following removal of sequestrum. Defect has been covered with Thiersch grafts



FIG. 3.—Shows burns over the right parotid gland and facial palsy. The peculiar expression of the eye is due to the cataract.



FIG. 4.—Indicates the extent of the injury to the feet. The flap covering the granulating surface above the left ankle anteriorly has been turned down from the side of the leg. This area has not yet been covered with grafts.

## ELECTRIC BURN CAUSING NECROSIS OF THE SKULL

genito-urinary system. Muscular movements are made normally without any incoördination. There are no changes in the nervous system which are marked. The patient complains of some numbness of the fingers, but there are no areas of anæsthesia, and also of some pain in the back.

There was quite a marked loss in weight after the accident. During the last few weeks there has been a gradual increase in weight and strength.

A peculiar reaction followed needling of the cataract which was performed under local anæsthesia. The temperature became sub-normal and the patient suffered for a few hours from a condition resembling quite severe shock.

There are recorded in the literature 13 cases of skull injuries caused by electric shocks which present much the same picture as that just described. The head has come in contact with a live wire carrying a high voltage, and has been severely burned. The associated injuries have varied, depending upon which part of the body has been in contact with a conductor. In one case there occurred a gangrenè of the arm which necessitated amputation. Five of these cases died. The case which I have described came in contact with a wire with a much greater voltage than any that has yet been reported.

In two of the cases the bone has been fused or destroyed as a direct result of the burn. In a fatal case described by Gerlach, a hole having a diameter of a dollar was burned down to the dura. In another fatal case described by Jellinek, the bones of the head contacted with the wire were fused, so that several small hollow bullet-like masses of calcium acid phosphate were formed.

In some instances the sequestrum separated very slowly. In this case separation was complete in a little over three months.

In none of the cases of the type under discussion, which have been reported, have eye changes been noted. Beginning eight weeks after the accident, a bilateral cataract developed. These have been operated upon by Dr. E. V. L. Brown. The cataract in the right eye has been removed, and apparently the retina has not been injured. Hemorrhages into the conjunctiva, clouding of the cornea, iritis, the development of cataracts, separation of the retina, optic atrophy, and paralysis of the eye muscles have been observed after lightning strokes, but as far as I know none of the cases of this type of electrical shock, except the one just described, have had any marked eye changes.

## DEEP PALMAR HAND INFECTIONS

A CLINICAL STUDY OF THE DIAGNOSIS AND TREATMENT OF THESE CONDITIONS

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THE most important part of the treatment of any infection of the palm of the hand is a correct diagnosis of the localization of the infection. A correct diagnosis of such localization demands a painstaking examination, a knowledge of the anatomy of the hand in its relation to infection, and a surgical sense which becomes sharpened by experience with this type of cases.

Infections of the palm of the hand may be divided between those lying above the palmar fascia and those lying below it. Those which lie above this fascia usually present no difficulty in diagnosis unless they are associated with infection also involving the deeper structures. This paper will discuss the infections lying deeper than the palmar fascia.

Infection deep in the hand may be localized in one or more definite anatomical positions, and by all odds the most important diagnostic features in the recognition of such localization are, first, the local areas of tenderness; second, the pain elicited by passive movements of the fingers and hand; third, the history or presence of a wound which is probably the initial source of the infection.

*Tenderness.*—To examine carefully the infected hand for the areas of tenderness will tax the patience of the surgeon to the utmost, and requires that, first of all, the complete confidence and coöperation of the patient must be obtained. The examination must be done slowly and methodically. The greatest accuracy may be obtained by using just the tip of the right index finger for palpation, or, better still, a blunt instrument such as the end of a pen-holder or a dull pencil. The patient's hand should rest lightly in the hand of the examiner, palm up, or on a table. It is best to begin the palpation at some distance from the area which is suspected of being the involved one. For instance, if the infection is probably in the middle palmar space, begin the examination over the wrist, or over the palmar thenar space. In this way the examiner will obtain an index of the patient's susceptibility and the patient will be reassured. In no condition is the individual's susceptibility to pain and tenderness more of a consideration than in these cases. Some highly sensitive patients will react vehemently upon the gentlest manipulation, making a careful examination extremely difficult; while a stolid few may allow of such coarse palpation as to raise the doubt that infection can be present. Furthermore, it should be borne in mind that even though the infection may be definitely localized in a certain compart-

## DEEP PALMAR HAND INFECTIONS

ment of the hand, the whole hand is more or less tender and it is not easy for the patient himself to give the physician a clear idea of its greatest intensity. In nervous patients the fear of having pain added to pain already intolerable will increase the sensitiveness of the individual to such an extent that the examiner must be careful not to be led away from the greatest localized tenderness by this apparently marked general tenderness. Tenderness will vary greatly, depending upon the acuteness of the infection—usually being very marked in the rapidly spreading virulent types and may be insignificant in those produced by organisms of low grade virulence.

*Pain on Motion.*—Characteristic is the position in which an infected hand is carried. It is with the fingers and thumb partially flexed at all the joints, and with the hand partially flexed at the wrist. This allows of the greatest relaxation of the muscles, and the least amount of tension between the tendons and their sheaths.

After the tenderness has been localized, gentle manipulation of the fingers and thumb must be made to determine what movements are painful and to what areas of the hand the maximum pain is referred. Here again it is best to begin with that finger the flexion and extension of which is likely to cause the patient the least amount of discomfort. As in the demonstration of tenderness, one must not be misled by the fact that pain is present on movement of all the fingers in some cases, but must discriminate between that which is more and that which is less intense. Increase of the partial flexion of the fingers will cause some pain, but extension is the movement which elicits the greatest amount, because it puts all the structures of the palm under tension. Each finger and the thumb must be examined separately, methodically, and, if necessary, repeatedly in order to determine accurately the relation of movements of the digits to pain.

The hand must then be examined relative to pain elicited by extension and flexion at the wrist, the former movement being more important than the latter.

*Local Signs of Infection.*—There may be a local wound, such as a puncture wound, hangnail, paronychia, etc., which will present evidences of inflammation and give a clue to the localization of the deeper, metastatic process. There is often some fulness in the palm of the hand, as shown by comparison with the sound hand, and may be evidenced only by an indistinctness in the lines of the palm. A very definite, diffuse bulging may be present, especially in children and in women, in whom the skin and palmar fascia is relatively thin and elastic. There is frequently an indefinite sensation of tension imparted to the palpating finger on examining the palm.

Cedema is usually limited to the back of the hand and is often so marked that the outlines of the knuckles are lost. Redness of this area is also present, and these two evidences of local inflammation are responsible for numberless incisions on the dorsum of the hand in cases in which not a drop of pus is present except in the palm. In marked contrast to the cedema and redness of the back of the hand is the relative absence of tenderness over this area.

These signs of redness and swelling vary with the localization of the infection in the palm and with the acuteness of the infection. Œdema and redness will sometimes be present on the palmar surface of the wrist in infections of the ulnar and radial bursæ. This is discussed later.

*General Symptoms.*—These vary as in pyogenic infection anywhere, and are of no distinct aid. In fact, their absence in low grade infections may cause one to distrust his local findings. I have seen a case in which over an ounce of pus was released from the ulnar and radial bursæ, in a patient who was observed for five days and who was denied earlier operation because the general symptoms of pyogenic infection were lacking.

*Localization of Infection.*—(a) *Ulnar Bursa* (Fig. 1).—Hand held semiflexed at wrist and with fingers and thumb partially flexed. Usually supported and elevated by well hand.

Tenderness, very severe in acute cases, is definitely localized over the ulnar bursa from the tip of the little finger to an inch above the wrist-joint, most marked usually in the region of the annular ligament and the wrist; less marked in the palm just distal to this ligament; usually associated with involvement of the radial bursa and tenderness over it.

Pain, very severe in acute cases, is elicited by extension of the little finger. This is referred throughout the extent of the tendon but its maximum intensity cannot be determined by the patient in most cases. On flexion there is also pain produced, but not so marked. Extension of the second, third, and fourth fingers produces pain referred to the palm of the hand, in *region* of the *carpus*, and wrist. Extension of the thumb will also refer pain to this region. Extension of the hand at the wrist causes marked pain referred to the wrist and proximal portion of the palm.

Redness is often present on the palmar aspect of the wrist just proximal to the annular ligament in the more acute cases, and when present is an extremely important sign of infection of the ulnar bursa. It extends across the wrist as a band about a finger's breadth in width, is somewhat œdematous, and usually very tender, superficially as well as deeply. Redness and soft œdema over the back of the hand is quite marked in acute cases and is uniformly distributed. Tenderness over this area, however, is slight. The presence of a local wound on the little finger, or a puncture wound in the palm directly over the bursa, will give a valuable clue to the localization of the infection.

(b) *Radial Bursa* (Fig. 1).—Tenderness very acute, and definitely localized over the tendon of the M. flexor pollicis longus from the tip of the thumb to about two fingers' breadth above the wrist-joint. Tenderness merges with that of the ulna bursa in the proximal portion of the palm in cases in which both are involved, which is the rule. One must be careful to differentiate the tenderness over the radial bursa from that over the palmar thenar space.

Severe pain produced by extension of the thumb referred along the entire tendon into the forearm. Severe pain also elicited by extension of



FIG. 1.—Areas of tenderness in infection of the ulnar and radial bursæ. The more marked areas of tenderness are shaded darker.



FIG. 2.—Area of tenderness in infection of the middle palmar space.



FIG. 3.—Area of tenderness in infection of the palmar thenar space.



FIG. 4.—Area of tenderness in infection of the dorsal thenar space.



FIG. 5.—Showing the skin incisions for drainage of the ulnar and radial bursæ.

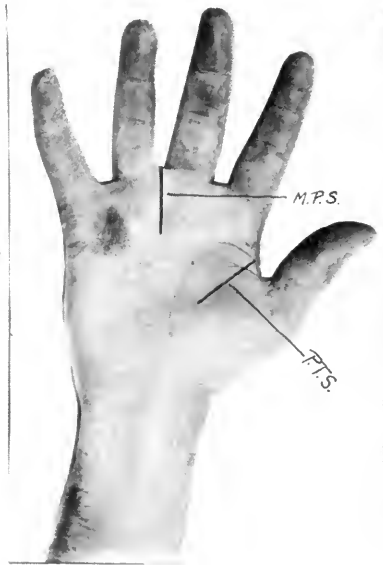


FIG. 6.—Showing the incisions for drainage of the middle palmar space and the palmar thenar space.



FIG. 7.—Showing the incision for drainage of the dorsal thenar space. The dorsal aspect of the middle palmar space incision is also shown.



## DEEP PALMAR HAND INFECTIONS

the hand at the wrist, referred to the region of the carpus. Movements of the second, third, fourth and fifth fingers will produce comparatively slight pain, and it will be referred to the region of the annular ligament and wrist. Œdema and redness over the palmar aspect of the wrist may be present. Over the back of the hand it is relatively slight and greater over the radial half than the ulnar. The presence of a wound of the thumb should make one suspect infection of this bursa.

Infection of low grade virulence will sometimes become walled off in a limited area of either the radial or ulnar bursa by adhesions forming between the synovial lining of the sac and that of the tendon. Practically this only occurs in those portions of these bursæ which lie in the thumb and little finger. Infection which gains access to the expanded portion of the bursa tends to spread rapidly throughout the entire sac.

(c) *Middle Palmar Space* (Fig. 2).—Tenderness is definitely localized over the area in the palm which this space occupies. This is usually not such an acute tenderness as is found over the ulnar bursa in infection of the latter. It extends only up to the annular ligament and is not present in the wrist. It is not present over the little finger and extends distally only to the transverse palm crease except where the space is prolonged along the lumbrical muscles of the third, fourth and fifth digits. Here the tenderness is often quite superficial.

Pain is elicited by extension of the middle and ring fingers. This is usually not very severe and is referred to the *middle of the palm*. Extension of the index and little fingers will produce pain relatively slight and referred also to the mid-palmar region. Extension of the wrist will cause only slight pain if the fingers are flexed, but if the fingers are extended either before or after extending the wrist, the pain will be severe and will be referred to the middle of the palm. Swelling and redness on the dorsum of the hand is usually quite marked and extensive. Tension and even bulging of the tough palmar skin is often distinct.

An infected wound of the middle or ring fingers, or one directly over the space, especially a punctured wound, often gives the first clue to the diagnosis. Emphasis must be made on the fact that infection in the mid-palmar space tends to early invade the palmar thenar space and *vice versa*.

(d) *Palmar Thenar Space* (Fig. 3).—Tenderness is localized in the palm over the space. It does not extend above the annular ligament nor onto the thumb. The extension along the lumbrical muscle of the index finger may often be definitely mapped out by the tenderness.

Pain is elicited by extension of the index finger and is localized in the palm just below the greatest prominence of the thenar group of muscles. Relatively slight pain is produced by movements of the remainder of the digits. Extension of the wrist produces no definite distress unless the index finger is at the same time extended.

Bulging in the radial half of the palm is often present and is quite diagnostic of infection in this space, and there may be redness over this area.

Œdema and redness on the back of the hand is present and is most marked over the radial half, especially between the thumb and index finger. An infection of the index finger is often the predisposing factor in infection of this space.

(e) *Dorsal Thenar Space* (Fig. 4).—Tenderness most marked on the back of the hand between the first and second metacarpal bones, and over this area there is usually a marked bulging and redness and œdema. Relatively less tenderness is present on the palm over the same area but extending also ulnarward nearly to the middle line of the palm. Pain is best elicited by abduction of the thumb and is referred to the web of the thumb. It is usually not marked.

Infection may spread to involve two or more of these bursæ or spaces, and if so, the diagnosis must be made of such involvement. Bearing in mind the anatomical relations between these various structures and the routes by which infection tends to spread as shown experimentally and clinically (Beye: *ANNALS OF SURGERY*, July, 1917), this is usually not difficult. To the area primarily involved are added the local symptoms of that secondarily infected as shown especially by the tenderness, and to a less extent by the pain of movement.

*Treatment.*—No attempt will be made to summarize the different methods of treatment which have been advocated by different surgeons. The methods which will be outlined in this paper have been worked out from study of clinical cases and anatomical preparations.

Deep hand infections should be treated as emergency surgical cases and operation must be performed as soon as possible after diagnosis is made. A delay of only a few hours may make a great difference in the extent of the infection. If there is a doubt in the mind of the surgeon as to whether infection is present in a certain space, it is safer to explore that space than to wait to see what is going to happen. Especially is this true if one is dealing with an acute infection. If an exploration is made of a space in the hand, and no pus is found, the chance for carrying infection into the space by the operative procedure is relatively slight.<sup>1</sup> If a space is watched for several

<sup>1</sup> Since writing this paper the following case has come under observation, which shows that exploration of an uninfected space is not without danger. Patient brought to hospital with a hand infection of four days' duration. Began within a few hours after a punctured wound of the thumb from the spur of a rooster. Diagnosis or infection of the radial and ulnar bursæ with extensive cellulitis of the forearm nearly to the elbow was made. Tenderness in the palm seemed more extensive than that produced by infection only of the ulnar bursa and seemed to extend into the mid-palmar space area. Exploration of this latter space was done and no pus was found. The opening was carefully packed with iodoform gauze and the ulnar and radial bursæ, which were filled with pus, then drained. The tough compact subcutaneous tissue around the exploratory incision for the mid-palmar space became mildly infected about the eighth day and this extended to involve the theca of the ring finger, and this bursa had to be widely opened. Notwithstanding this unfortunate result from an exploration I believe that the principle remains the same, *i.e.*, that in acute hand infections exploration of doubtfully infected spaces is less dangerous than waiting to see what is going to happen.

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hours, and it already contains pus, considerable damage may be done during the delay.

A general anæsthetic should be given in the vast majority of cases, because complete relaxation is essential to careful work, and ether is by all odds the anæsthetic of choice. Nitrous oxide and oxygen may be given satisfactorily by a skillful anæsthetist.

A constrictor should be used unless there is a contra-indication to its use. It allows of careful scrutiny of the blood-free tissues and the detection of small amounts of pus which might be easily overlooked. Its use is contra-indicated if there is a lymphangitis which extends up as high as the elbow or above. The most common complication attributable to its use is a thrombophlebitis of the superficial veins of the forearm.

Tincture of iodine is used to render the entire hand and forearm aseptic. In all cases the operative procedure should be carried out carefully, methodically and along certain definite lines.

*Ulnar Bursa* (see Fig. 5).—An incision is made parallel to the flexor tendons to the little finger and directly over them at the point of greatest tenderness in the palm. As the deep palmar fascia is divided it will often appear distinctly cedematous—a reassuring evidence of trouble in the deeper bursa. As the latter is come upon it may be distended and tense by the accumulation of pus within it. In the early cases, however, it may only appear lusterless, or there may be no evidences from the outside, of trouble within it. Make a small incision in the bursa, taking care not to injure the synovial lining of the tendon, and frequently pus will at once roll out from it, or at least a cloudy, sticky fluid. The latter type of exudate is characteristic of a very acute streptococcic infection in the early stage.

In some cases there is no evidence of exudate or pus upon opening the bursa, to the dismay of the operator. Gently strip the ulnar bursa, beginning in the forearm and continuing distally to the opening which has been made in the bursa. This will produce pus if present in the bursa in the wrist and forearm. Similarly pressure upon the distal portion of the bursa will demonstrate the presence of pus here.

As soon as free pus in the bursa has been demonstrated, the latter must be widely opened. Remember that the tendon of the fifth finger is the guide to the bursa and that the tendon may be easily mapped out by bearing in mind its relation to the uncinatè process around which it swings as it passes from the wrist to the palm of the hand. This bony landmark is readily palpable.

First extend the incision through the *skin* and *tough subcutaneous tissue* from the distal phalanx of the fifth finger to a finger's breadth proximal to the annular ligament in the wrist, exposing the ulnar bursa and the annular ligament where the bursa passes behind this ligament in the wrist. Then carefully open the bursa where it lies over the flexor tendons of the fifth finger, by enlarging the small incision which was previously made in it, from the distal phalanx to the distal border of the annular ligament, leaving a narrow strip of the bursa intact at the levels of the metacarpophalangeal joint

and the first interphalangeal joint, where the bursa is reinforced by a tough band of deep fascia. These intact strips prevent prolapse of the tendon in the finger, with subsequent better function.

How to take care of that portion of the bursa which lies under the annular ligament is always a question. At the proximal margin of the annular ligament there is just a very small bit of the bursa which extends anterior to the tendons and that is on the ulnar side. The greatest portion of the bursa lies behind the group of tendons. But under the ligament as the palm is approached, more and more does the bursa tend to extend anteriorly. Whether the annular ligament should be cut through or not will depend upon several factors. I do not believe that it should be done in all cases. Unquestionably by completely incising the ligament better drainage is obtained, but in many cases sufficient drainage is gotten by leaving the ligament wholly or partially intact. The disadvantage in incising completely the annular ligament is the danger of prolapse of the tendons. This may be guarded against by dressing the hand in extension as has been advised, but by so doing the tendons are pressed firmly against the posterior wall of the bursa and tend to dam in the pus, thus defeating the purpose of this manoeuvre. Furthermore there is no doubt that healing takes place with greater danger of scar interference in those cases in which the ligament has been incised. In a given case, however, there should be no hesitancy in doing this more radical procedure if there is the question of insufficient drainage on the one hand, and that of scar formation or tendon prolapse on the other.

(1) Leaving the annular ligament intact. This may be done in acute cases which have been gotten early and in which there has been only a small amount of pus formed, or in which the pus is thin and readily drainable. It may be done in those cases in which the bursa extends well up into the wrist *anterior* to the flexor tendons, for in these a considerable drainage may be established by incision proximal to the ligament. In low grade infections this may be sufficient unless the pus is very thick, as is frequently the case. That portion of the bursa lying proximal to the ligament and anterior to the tendons should always be opened, whether the ligament be wholly or partially incised or left intact. To do it a grooved director is passed into the opened bursa just above the tendons of the little finger at the distal border of the annular ligament, and guided under the latter toward the wrist. Care must be taken not to use too much force so as to injure the tendons. The bursa proximal to the ligament may thus be opened on the director.

(2) Cutting the annular ligament. This may be done partially or completely, depending upon the necessity. In acute cases with formation of considerable pus which seems to have accumulated under the annular ligament, in cases in which the bursa does not extend proximal to the ligament anteriorly, and in neglected cases in which involvement of the carpal joints and bones is feared, then the annular ligament should be cut in some degree depending upon the condition present. The preservation of even a small

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portion of the ligament should always be done where deemed advisable. It will aid in maintaining the "status quo."

To do it, a grooved director is passed from below up, under the annular ligament, and the incising done upon it. In those cases in which the ligament is completely incised, the whole tendon group may then be very carefully lifted out from its carpal bed and the pus lying under it gently sponged or washed away. Rough handling must be avoided, because of the sensitiveness of the synovium.

Drainage of that portion of the bursa which lies *behind* the tendons in the wrist and forearm must now be made, and here is found the greatest amount of pus in most cases. An incision is made on the ulnar side of the forearm hugging the anterior surface of the ulna. This begins at the level of the wrist-joint, extends up the forearm for about  $2\frac{1}{2}$  inches, passing through the skin and fascia to the bone. Then a pair of sharp-pointed hæmostats is forced through the incision, keeping close to the bone and under the flexor tendons, and passed toward the palm directly into that portion of the ulnar bursa which is so intimately related to the carpus. Then the forceps are spread and withdrawn and the pus will roll out along them.

When both ulnar and radial bursæ are involved the radial bursa is drained by a similar incision made along the radius, which will be described later, and then through and through drainage is instituted through the bursæ, by passing a hæmostat from the ulnar incision to the radial incision under the tendons. Drainage is maintained by the use of gutta percha tissue folded into strips. This material may be made to fit into the incision readily, is non-irritating and allows pus to escape along it freely. If it is not available, the next best is strips of plain gauze dipped into liquid paraffin. The incision in the hand is held widely open in its entire extent by laying into it, down to the exposed tendon, a strip of gutta percha. That portion of the bursa behind the tendons in the wrist and forearm is drained by two folded strips of gutta percha carried through the ulnar incision, one laid in the trough of the carpus without using force, and the other out through the radial incision upon the pronator quadratus muscle.

*Radial Bursa* (see Fig. 5).—In this case the mode of procedure is similar to that in infection of the ulnar bursa. It should be again emphasized that the branch of the median nerve passing to the thenar group of muscles must be spared, even at the expense of insufficient drainage of the bursa, with subsequent loss of the flexor tendon to the thumb. This nerve branch lies within a finger's breadth of the distal margin of the annular ligament.

Make an incision from the distal phalanx of the thumb to within a finger's breadth of the annular ligament through the skin and subcutaneous tissues directly over the tendon of the flexor longus pollicis. Remember that this tendon passes at an angle of 60 degrees around the trapezium with the thumb abducted. Retract the thenar muscles to the outside and open the radial bursa for the extent of the incision in the soft tissues. Make another incision about an inch in length on the anterior surface of the wrist proximal

to the annular ligament and incise the radial bursa at this point. The portion of the bursa lying behind the tendon in the forearm and wrist is drained by a lateral incision about 2 inches in length made along the anterior border of the radius. Through this incision a hæmostat is passed behind the tendon down into the carpal trough and the bursa widely opened.

These incisions are kept open by folded gutta percha strips laid down to the exposed tendon and the portion behind the tendons in the wrist is drained by a strip carried into it through the radial incision.

*Middle Palmar Space* (Fig. 6).—In the usual case this is best drained by the method first advised by Besley. Holding the middle and ring fingers widely apart, split the web between them to the level of the distal transverse crease of the palm anteriorly and posteriorly to the level of the knuckles. Then retracting the incision by spreading the fingers, carefully pass a hæmostat behind the tendons upward toward the annular ligament. Then gently spread the points of the forceps and withdraw. The pus will roll out along them.

If the infection has travelled down along the lumbrical muscle of the middle or little finger, then it is advisable to drain the middle palmar space by incising the web between the index and middle fingers or ring and little fingers respectively. In the latter instance care must be taken not to encroach upon the tendon of the little finger with the ulnar bursa surrounding it. In a very exceptional case it may be wise to incise into more than one web to provide adequate drainage.

The incision is kept open by a folded gutta percha strip which is very carefully carried to the depth of the space by a hæmostat.

*Palmar Thenar Space* (Fig. 6).—Make an incision beginning just above the web between the thumb and index finger half way between the thumb crease and proximal palm crease. Carry this obliquely upward and inward toward the point at which the flexor tendons to the thumb and index fingers diverge in the palm. The incision passes through the tough palmar skin and fascia to the M. adductor pollicis. This opens the palmar thenar space. A hæmostat is then carried through this incision toward the annular ligament, keeping behind the flexor tendons of the index finger, and withdrawn with jaws spread. Drainage is maintained by a gutta percha strip laid in the incision and carried to the highest point of the space.

*Dorsal Thenar Space* (Fig. 7).—Incision is made on the dorsal surface of the hand beginning just above the web between the thumb and index finger and carried up for about one inch parallel to the first metacarpal bone. This exposes the margin of the first dorsal interosseous muscle and a forceps is inserted just anterior to this muscle and behind the M. adductor pollicis and carried in deeply to the depth of the space; *i.e.*, the level of the origin of the latter muscle from the third metacarpal bone. Drainage is maintained by a gutta percha strip.

If more than one compartment of the hand is infected, it will be necessary to drain each involved area. This is very important, as so frequently

an infection which has primarily attacked one space will have subsequently spread to one or more others, and drainage of that primarily involved will not be sufficient to take care of those secondarily involved. To many surgeons the incisions as outlined above seem very radical, whereas, early, free, complete drainage of an infected hand along definite anatomical lines is in reality conservative surgery. I can conceive of no condition in which through and through tube drainage of the hand would be indicated.

After the necessary incisions have been made and the gutta percha drains placed, then the constrictor is removed. There is free oozing of blood, but it is rare that a ligature must be applied, for the bleeding soon stops. If the annular ligament has been completely incised then dress the arm on a dorsal board splint with the wrist and fingers held flat against it so as to prevent prolapse of the tendons. Where the ligament is completely or partially intact a splint is not desirable, but the thumb and little finger should be kept straight by the dressings and bandage. Hot boric dressings are applied to the whole hand and forearm, care being taken not to cramp the fingers by the dressing or bandage, as this causes a great deal of discomfort. They should be kept hot and moist by repeated irrigation.

*After Treatment.*—Hot, moist dressings are usually discontinued after forty-eight hours and are replaced by plain gauze dressings spread thinly with sterile vaseline to prevent injury of the granulations. In applying the bandage to the dressing the unincised digits should be left free so as to allow active and passive movement of them, as well as giving the patient more comfort. The drainage material is removed also at the end of forty-eight hours, for if the incisions have been ample there will be sufficient drainage through them from now on. Particularly in the infections of the radial and ulnar bursæ it is desirous to remove the drains just as soon as possible, so as to obviate any danger of injury to the synovial lining of the tendons by pressure from the drains.

Beginning on the third day, the hand is soaked every day for fifteen minutes in a hot bath to which is added tincture of iodine. At first just enough of the latter is added to color the water, and each day more is added so as to make the soaking more stimulating to the granulating areas. As early as the third day, while the hand is soaking in the hot iodine solution, passive motion of the fingers is very gently begun and the patient is encouraged to attempt active motion. This is continued each day, more and more force being used, but always being careful not to do more harm than good by excessive injury to the granulation tissue. In infection of the ulnar and radial bursæ, early mobility of the second, third and fourth fingers must be worked for, for the fingers are often annoyingly stiff, due to long continued immobilization as well as the inflammation of the bursæ.

It should be emphasized that an infected hand which has been drained should be examined carefully each day in order to make sure that all of the infected areas have been opened and that the drainage has been ample. If an infected area has been sufficiently drained, tenderness should no longer

be present over that area. If tenderness develops over a space which has not been drained, involvement of that space must be at once suspected. The pulse, temperature and leucocyte count are valuable adjuncts as they are in infection in any part of the body. But in an old, neglected hand infection, pus may be present or may even spread to involve a new area without variation in the pulse, temperature or leucocytes giving a clue.

*Prognosis.*—When the ulnar and radial bursæ are drained for infection throughout their extent, there is never a 100 per cent. recovery of function. Interference with function varies, naturally, with the time which elapses between the onset of infection and the drainage of the bursæ; whether there is loss of tendon, involvement of the wrist or carpal joints, whether the annular ligament was incised, and the will of the patient to work the hand during convalescence.

One of the end results which may occur even under the best conditions of treatment is contracture of the little finger. There is always stiffness of the finger at least. If the contracture is at all marked, amputation is the best treatment. Lesser degrees may be treated by excision of the scar in the finger and portion of the palm with transplantation of a Wolff or pedicle flap. The end result after such procedure is only fair.

Contracture of the thumb is usually less marked than that of the fifth finger, and would almost never call for amputation.

Return of function after uncomplicated infection of the middle palmar, palmar thenar or dorsal thenar space may approximate 100 per cent.



## BONE TRANSPLANTATION IN THE SURGICAL TREATMENT OF PARALYTIC FEET

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THE object of this operation is to secure bony ankylosis and so assure stability and prevent lateral deformity of a flail ankle, fixing it in a position of equilibrium midway between flexion and extension. This is done by inserting a bone graft which passes through both malleoli and the body of the astragalus.

While numerous operations have been devised for improving the function of paralytic feet, the end-results have been unsatisfactory. It is irrational to expect that a mere shortening of tendons which often are so stretched out, leaving only a thin membranous structure, will cure a deformity so complex. Tendon transplantation has proven disappointing in not fulfilling expectations, relapses occurring in a few years with the return of the deformity. Arthrodesis alone of the ankle-joint, in my opinion, is an operation yielding, at the best, an imperfect result and should not be encouraged. To increase security of the foot, in paralytic feet, Whitman advises arthrodesis, astragalectomy, tendon transplantation, and backward displacement of the foot. Goldthwait has evidently been unsuccessful with arthrodesis alone; he, in an attempt to secure a closer fitting of the parts, performs an oblique osteotomy of the lowest part of the shaft of the fibula. The lower end of the fibula is then bent inward and pressed against the external articular surface of the astragalus.

To prevent recurrence of the deformity, I devised the method of bone transplantation which will be described presently. My first case operated by this method was on October 9, 1915. The patient, Fannie R., aged nine years, had suffered from infantile paralysis for six years, affecting the muscles of the left leg. The plaster cast was removed at end of 8 weeks. Primary union, foot firmly ankylosed at angle in normal position. The operative technic for the proposed procedure is as follows:

- 1.—Prepare foot and leg for operation and apply an Esmarch bandage.
- 2.—Place the outer side of the foot on a sand bag.
- 3.—A short curved incision is made passing from a point behind the internal malleolus, below its extremity, and terminating in front of it.
- 4.—The limb is now turned over, the inner side resting on the sand bag, and a second incision is made passing from a point behind the external malleolus, below its extremity, and terminating just below and in front of the joint. The joint is then opened and the foot displaced inward. This forces the astragalus from between the malleoli. The cartilage on its upper

and lateral surfaces is then removed. The foot is now forced downward, and the articular surfaces of the tibia and fibula are likewise removed.

5.—A hole is made with a quarter-inch drill passing through both malleoli and the body of the astragalus.

6.—Measure the length required for the bone graft by inserting a flexible probe into the canal just made, marking by bending it at a right angle.

7.—With a chisel or motor saw remove the needed bone of the measured length and thickness from the upper third of the anterior internal surface of the patient's tibia. The graft must be of sufficient thickness to necessitate a moderate amount of force to insert it into the canal, since bone will only unite when it comes in intimate contact, otherwise granulation tissue appears on the wall of the canal, interfering with nutrition and predisposes to the absorption of the bone graft.

8.—Insert bone graft into canal ready to receive it.

9.—Suture the anterior and lateral ligaments, then close the wound with catgut.

10.—Plaster-of-Paris fixation dressing from eight to ten weeks.

The advantages of this operation are: (1) The three bones of the ankle are fixed by one bone graft. (2) It is much simpler and easier of execution than other operations known for this condition. (3) It is less mutilating. (4) It does not injure the epiphysis of the tibia as does the bone graft insert of Lexer, who advises a graft which passes through the os calcis, astragalus, and tibia. (5) It preserves the joint between the os calcis and the astragalus, thus allowing some degree of mobility.



FIG. 1.—A and B, showing position of bone graft passing through both malleoli and the body of the astragalus.



FIG. 2.



## NOTE ON TUBERCULOSIS OF THE SPINE

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THE opportunity for studying vertebral tuberculosis in a patient before the bones are attacked and after pathological changes have occurred is not often presented. The following case is therefore of interest in this respect.

**CASE HISTORY.**—E. W. entered hospital August 16, 1915. Age, forty-four. Female; married. Provisional diagnosis, *movable kidney*.

**History.**—Pain in small of back and right side of abdomen. Began about three and one-half months previously with sudden onset. Pain over right kidney and in right side of abdomen. Pain severe and of a few days' duration. Incontinence of urine and nocturia. Also blood-tinged urine with some mucus. Condition gradually improved. After being in bed for three weeks pain was less severe. Up to two weeks ago patient was up and about. Second attack, similar to the first, then occurred. Pain was more severe and definitely localized over right kidney and right side. Frequent micturition.

**Family History.**—Father died at thirty-nine years of age of tuberculosis of stomach. Mother died at age of forty-one of pulmonary tuberculosis. One brother died of stomach trouble at forty-five. Husband and two children living and well.

**Past History.**—Has never been strong, although not troubled with any disease; subject, however, to sick headaches for many years. Some shortness of breath for the last two years. Bowels have always been constipated. Has also complained of rheumatism in the extremities for several years. Catamenia normal. Best weight 98 pounds, two years ago.

**Present Illness.**—Since onset of present illness has had night sweats but no cough. Present temperature 99.8°; pulse 90; respiration 20.

**Physical Examination,** August 17, 1915.—Left side of abdomen negative. Right side, lower quadrant, just below McBurney's point, a localized area of tenderness without muscular spasm. Right kidney movable, readily palpable and tender. No abdominal distention. Posteriorly, marked tenderness in both costovertebral angles extending down the lumbar muscle. Facies indicates loss of weight.

**Cystoscopic Examination.**—Meatus small. Left side, normal flow of clear urine; right side, delayed flow of clear urine.

**Operation,** August 27.—Right kidney low and movable. Definite perinephritic kidney being adherent to posterior peritoneum. No stone in kidney or ureter. Liver and large bowel very low; liver opposite anterior superior spine. Long, thick, chronically inflamed appendix. Left kidney normal. General visceroptosis. Wound closed; no drainage.

September 9: Wound practically healed.

September 15: Incisions completely healed.

September 19: Discharged, apparently cured.

Patient readmitted to Dr. John W. Churchman's service June 1, 1917.

Diagnosis, *tuberculosis of the spine*.

*History* of abscess and later discharging sinus in kidney region and back trouble. After being discharged from the hospital in September, 1915, felt fairly well, excepting for rheumatic pains about the waist and appendix region. Shortly after operation patient began to notice that her back was "getting out of shape." In January, 1917, began to have trouble in using her legs. Had pains, and a short while ago her heels began to feel numb. On urination had definite sharp pains in her side. In January, sinus opened at the site of the old wound; has been discharging since. Complains of indigestion. Constipation. No loss of weight. No cough or expectoration.

*Physical Examination*.—Shows a rather poorly developed and nourished middle-aged woman. Color of face is high, but skin is generally pale. Conjunctiva of eyes pale. Tongue slightly coated. Moderate gingivitis present. *Teeth*—upper, false; lower, fairly good. *Neck*—chains of shot-like glands in cervical region; palpable; most marked on the left. Axillary glands size of cherries—easily palpable. Epi-trochlear glands palpable and inguinal glands moderately enlarged. *Thorax*—small, round and long. Ribs and clavicle prominent. Expansion is slightly better on the right than on the left. Left supra- and infraclavicular fossæ prominent. Left apex narrowed and dull posteriorly down to spine of scapula and in front to the second rib. No definite râles. Breath sounds slightly diminished and slightly harsher over the left apical region. Lungs are otherwise hyperresonant. *Heart* negative. *Abdomen* natural; scars from previous operation. No masses over areas of tenderness. *Spleen* slightly enlarged. *Liver*—normal size; sixth rib to 1 cm. below costal margin in right midclavicular line. No palpable mass. *Kidneys* not palpable. In right lumbar region, in old kidney operation scar, is a small sinus discharging thick yellow pus. Marked tenderness over lower ribs and posteriorly over both kidney regions. Back shows small gibbus opposite first lumbar. Region quite tender. *Extremities*—no paralysis. Feet and hands cold and sweaty. Feet cyanotic.

*Neurological Examination*.—Knee jerks and plantar reflexes present but not lively. No Babinski or Kernig. Sensation of lower extremities somewhat modified. Posterior and lateral surfaces of both thighs, legs, outer half feet, and ankles show diminished sensation to touch. Pain sense and heat sense diminished on outer part of dorsa of feet and over an area the size of a hand, just back of the trochanters.

Patient referred for röntgenological examination on June 2, 1917. *Diagnosis*, tuberculous kidney (right). Pott's disease. *X-ray Diagnosis* (Fig. 2).—Just below the right kidney region, opposite the psoas muscle and opposite the third lumbar intervertebral space, there is an area 3 cm. long and approximately 1 cm. wide, the density of which is similar to bone. There are several other smaller opaque



FIG. 1.—Röntgenogram taken August, 1915, shows normal vertebræ (I, II and III). Arrows point to areas of calcification.

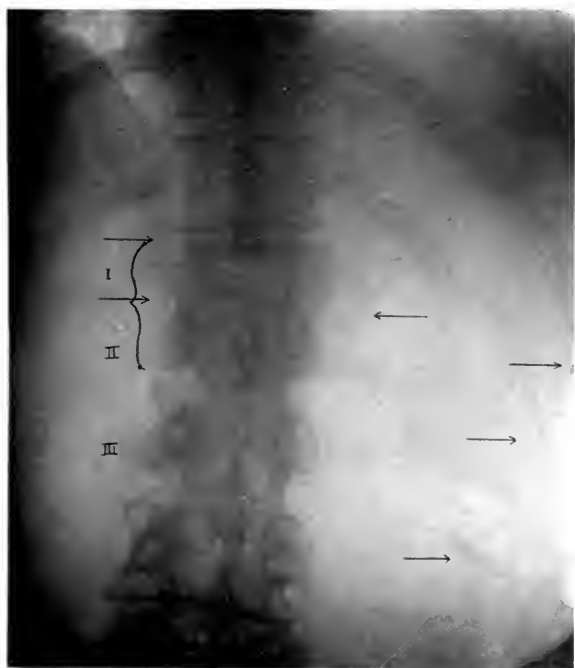


FIG. 2.—Röntgenogram taken June, 1917 (twenty-two months later), shows destruction of vertebræ (I and II). III and IV show rarefaction changes. Arrows point to areas of calcification. Right lower arrow shows the same area of calcification mistaken for calculus; marked calcification surrounding destroyed vertebræ.





## TUBERCULOSIS OF THE SPINE

areas at the ends of the ribs and at the outer borders of the first and second lumbar vertebræ. The left kidney region shows a more or less similar condition. A-P view of the spine shows a marked bony change in the first and second lumbar vertebræ. There is apparently complete destruction of the body of the first lumbar vertebra with absorption of bone substance and irregular redeposit of bone salts. Lateral view shows a greater destruction of the anterior portion of the first lumbar. There is also destruction of the upper and anterior portion of the second lumbar. The whole spine shows a marked kyphosis at the first lumbar vertebra.

The chest shows an increased density throughout both lungs. The bronchial markings are much increased in density and width. There are definite calcified tubercles and mottling extending everywhere. Both apices show the greatest density. There are definite calcified glands in the region of the hilus and in the neck.

These röntgenograms were compared with the röntgenograms made in August, 1915, previous to operation (Fig. 1). The areas in the kidney region are as described in the present examination—perhaps slightly smaller and less abundant. The vertebræ in 1915 show absolutely no changes and would be considered normal.

Diagnosis of the present condition is unquestionably that of tuberculosis—probably miliary.

In the case under observation there are several other points to be noted. Tuberculosis of the vertebræ occurred by extension from a neighboring lesion aggravated by operation on a tuberculous kidney. In the large majority of cases the vertebræ from the eighth or ninth dorsal to the third or fourth lumbar are most often attacked, and the process when seen by röntgenological examination is advanced, either showing as a more or less fusiform enlargement covering two or more vertebræ with increased density over the vertebræ (this is the so-called "condensante" form), or showing destruction of bone with obscurity of outline and detail and with obliteration of the intervertebral spaces, and adjacent rarefying changes. In the first type the fusiform enlargement is the result of tissue reaction—granulation tissue formation—as the process begins superficially, then new growth and formation of bone predominating at the level of the periosteum. In the second type the changes are rapid, especially in the adult, with slight, or no, external tissue reaction. The extremely favorable cancellous nature of the vertebral body with its abundant blood-vessels favors absorption with resulting rarefying changes, irregular surface erosion, vascular changes giving rise to caseous lesions and then mechanical forces which cause anterior compression, collapse and deformity (see Figs. 3 and 4).

These last changes are seen in this case and the rapid progress of the disease is evident. There is also seen here an external bone reaction with irregular deposits of lime salts immediately around the affected vertebræ and with unusually abundant lime salt deposits in the sternal portions of the ribs—especially in the ends of the last ribs on both sides—as well as

in the cervical, axillary and bronchial glands and the renal regions, suggesting a similarity to metastatic calcification.

The other classical features are not lacking here, such as abscess formation and failure to heal. The examination also reveals a pulmonary and gland tuberculosis. A tuberculous family history is given. Surgical trauma was a factor.

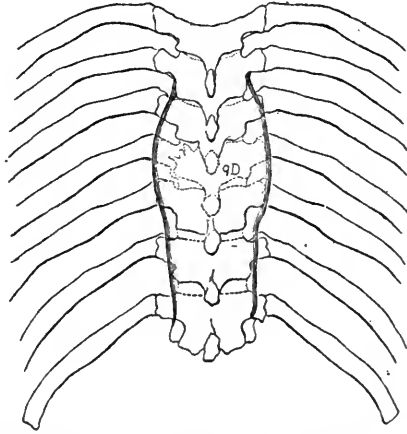


FIG. 3.—Illustrates a case of fusiform type of tuberculosis involving the seventh, eighth, ninth, tenth and eleventh dorsal vertebræ, especially the ninth and tenth. (Drawing made from röntgenogram.)

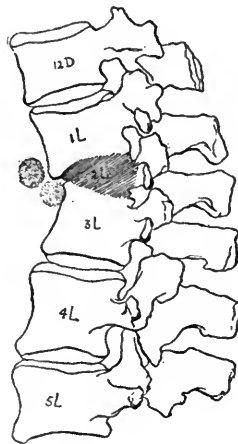


FIG. 4.—Shows destructive type of tuberculosis affecting part of the first, all of the second, and part of the third lumbar vertebræ. (Drawing made from röntgenogram.)

Lannelongue's assertion that bone lesions most often have a visceral lesion is here borne out.

One may conclude from this case that the diagnosis of renal calculi was based originally on the areas of calcification in the right renal region, but which, on closer study, are shown also on the left side and in the distal

## TUBERCULOSIS OF THE SPINE

ends of the last two ribs. Failure, therefore, to make proper diagnosis resulted in operation. The operative finding of "definite perinephritic kidney being adherent to posterior periosteum" points to inflammatory changes which were undoubtedly tuberculous in origin. The lighting up of this focus gave rise to the bone lesion. It may be pointed out that except in diseases where bone destruction is great, the redepositing of lime salts in tissues usually free is seen most frequently in case of tuberculosis. Renal pain, when occurring unilaterally, is often referred to the side free from disease and is therefore of less value than the röntgenological evidence. In cases similar to the one presented here the presence of calcified areas indicates at least further examination to determine whether tuberculosis can be ruled out. Two facts, röntgenologically speaking, are to be borne in mind: the renal region is not fixed and the opaque areas in the renal region do not always mean calculi. The following case is added to emphasize this:

Female, aged thirty-five, with the diagnosis of pulmonary tuberculosis and bilateral renal tuberculosis, was admitted to Dr. Willis E. Hartshorn's service. The history was that of pain in the left side for several years which has become very severe during the last three months. Loss in weight, 25 pounds. Cystitis for the last three weeks. Physical examination gave pain and tenderness over left kidney. Left kidney easily palpable. Right kidney is 3 cm. below rib margin and slightly tender to pressure. The chest examination is omitted. The patient was referred for röntgenological examination. Röntgenogram of lungs suggests tuberculosis. Röntgenogram of renal region on the left is negative; on the right, opposite the third lumbar vertebra and 4.5 cm. from the outer vertebral border, is an opaque area—approximately 7.5 by 4.5 in diameter—with a vague inner outline but with a definite semicircular outer outline. Ureter catheters were inserted and röntgenograms repeated, which showed the left ureter to be in normal position and outline and to extend to opposite the first lumbar vertebra, approximately 3.5 cm. from vertebral border (normal position); the right ureter showed a less normal outline and stopped opposite the third lumbar vertebra, 3 cm. from the vertebral border, 3 cm. from the opaque area previously described. Diagnosis of pathological kidney was made, probably tuberculous. Exploratory operation advised. Examination for acid-fast bacilli advised. Patient was cystoscoped, cloudy urine obtained from right ureter. Acid-fast bacilli found.

It is suggested, therefore, that in such cases follow-up treatment be instituted. Had this patient (E. W.) been reexamined at three-month intervals, the bone changes described, as well as the other visceral changes, could have been determined by röntgenographic methods.

# THE GENERAL PRINCIPLES OF TREATMENT OF WOUNDS OF THE KNEE-JOINT FROM PROJECTILES IN WARFARE

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THE experience of the present war, an experience of now three years, has completely overturned the practice of former recent wars, and this statement applies very particularly to wounds of the large joints from rifle bullets and artillery projectiles. Wounds of the knee-joint represent from 3 to 4 per cent. of major injuries inflicted in battle, and that they are serious can be best judged from the fact that the resulting mortality may be placed at about 18 per cent. This gravity is increased on account of the numerous complications to which the knee-joint is particularly exposed, such as secondary hemorrhage, thrombophlebitis, gas gangrene and sepsis.

The anatomical varieties of wounds of the knee are many, but may be roughly classified as follows: (1) Seton or tunnel wounds without fracture, the bullet passing directly through the joint or remaining free within. This latter event is not common. (2) Wounds with fracture of one of the bones composing the joint, such as crushing of the tibial plateau, crushing or comminuted fracture of the patella or the femur, one or both condyles being broken off or crushed. (3) Wounds resulting in fracture of both tibia and femur, usually accompanied by fissures extending into the knee-joint. (4) Wounds with crushing of the articular surfaces, frequently with extensive destruction of the surrounding soft structures.

I am convinced that certain surgeons are prone to amputate with far too great a readiness in wounds of the knee, particularly when there is fracture, as is usually the case, as they fear the advent of a suppurating arthritis which cannot be overcome by arthrotomy or resection, and as they assume that the sepsis cannot be controlled they amputate, if not at once, at all events very soon—that is to say, within four or five days following the receipt of the injury. Now, this practice is bad and can only be condemned.

When should amputation be resorted to? To this question the answer is easy. Amputation is absolutely and unquestionably indicated (1) when there is crushing of the knee-joint or when the surrounding soft structures and bones forming the joint are so destroyed that they cannot be saved; (2) when there is a wound of the knee with injury to the large vessels in the popliteal space, but ligature may first be done if this is possible and an attempt made to preserve the limb, although *generally* the result will be unsuccessful; (3) *immediate* amputation must be done when there is gangrene of the leg, or when a *purulent arthritis is complicated by secondary hemorrhage from the popliteal artery* as occasionally happens. Never try to ligate in these cases; you will surely lose your patient.

## TREATMENT OF WOUNDS OF THE KNEE-JOINT

*The important principle to follow is to disinfect the wound and then obtain thorough drainage and immobilization of the joint.* This is accomplished by arthrotomy with removal of the projectile in cases of wounds without fracture. The technic will vary with the preference of the operator, but I advise you to resort to the U-incision or a long external incision, this particularly when the projectile is retained in the joint.

Typical subperiosteal resection, according to the teachings and technic of that great master of bone surgery, the late Professor Ollier of Lyons, should almost always be done *as soon after the injury* as possible: by this I mean within the first twelve to twenty-four hours; but if an important portion of the articular surface can be preserved *without interfering with free drainage*, one may occasionally perform an atypical resection. But I repeat that a typical resection is the only proper treatment in the vast majority of cases. By resection the entire wound is cleansed of all bone splinters and bits of clothing and projectile are removed, so that when the operation is completed the wound is as aseptic as is possible to make it, and if the after treatment is properly carried out the recovery will be rapid and devoid of any disagreeable surprises or complications. *Never suture the wound after resection; leave it open without a single stitch being taken.* Immobilization will be obtained by a proper plaster case which will be described farther on.

*Penetrating wounds of the knee-joint by projectiles without lesions of the articular ends of the bones, the projectile having made its exit from the joint cavity*, have been relatively frequent, although seldom met with other than in this joint. Simple capsular injuries without damage to bone are not uncommon, the bullet passing through the suprapatellar pouch or the intercondylar notch, sometimes transversely behind the ligamentum patellæ if the joint is flexed at the time the projectile strikes. When seen within the first twenty-four hours after receipt of the injury, the knee is already swollen and an entrance and exit wound will be found diametrically opposite each other. The first thing to do is to take the patient's temperature, the result being that we have one of two conditions, viz.: (1) A wound of the knee with two apertures and apyrexia, or (2) a wound with two apertures with a rise in temperature.

When there is apyrexia it is *probable* that the lesions to the joint are not serious, and rest in bed, compression and immobilization in a fracture gutter will soon cause the swelling to disappear. If at the end of three to four days the intra-articular fluid collection, which is due either to a reaction of the synovial or to lesions of its vessels, has not become absorbed, it is preferable to empty the joint. Never use an aspirating needle for this, because the trocar will surely become obstructed by the gelatinous fluid or blood-clot which forms the collection and the inevitable result will be that the fluid contents is not withdrawn and probably you will infect the joint at the same time. Therefore, make a small incision and empty the joint cavity, irrigate with salt solution, and thus you will hasten the patient's recovery and at the same time do away with the possibility of sepsis. You will also avoid, by this simple

surgical procedure, most of the consequences of intra-articular collections, such as muscular atrophy, stiffness in the joint and the development of adhesions.

After the joint cavity has been cleaned out, the small incision in the capsule is closed with catgut sutures, the entire operation having been as aseptically carried out as an abdominal operation, otherwise you will meet with disaster. A compressive dressing is applied which should not be removed for five or six days, if all goes well, and the limb immobilized in a wire gutter. At the end of a week recovery will be far advanced and the patient will have retained the totality of movements in the joint.

When there is pyrexia it is ordinarily the result of an infected hæmatoma and the immediate prognosis is more serious, while expectant treatment would be a very grave mistake.

Arthrotomy is indicated and should be undertaken without the least delay. An incision should be made on each side of the patella and a rubber drain inserted into each. The tubes are retained in place by a silkworm-gut suture uniting them to the skin incision. After washing out the joint contents with sterile salt solution, the limb is immobilized in a posterior plaster case, and the limb elevated. All pain ceases immediately and the joint is placed in absolute rest.

The joint is irrigated once or twice daily with sterile salt solution or with some *very mild* antiseptic solution if preferred, after which it is good practice to spray the joint cavity with ether. But as soon as there is apyrexia and the wound has taken on a nice red look, irrigation is to be stopped and aseptic dry dressings applied every two or three days according to the amount of discharge, and the drains are removed. Intra-articular blood collections can be safely opened when aseptically done even in ambulances at the front. Classic arthrotomy for pyarthroses of the knee-joint, without the presence of the projectile and without damage to bone, is useful only as far as evacuation of the pus is concerned and immobilization of the joint in a plaster case is the principal factor in the cure, since it acts by overcoming the inflammation. I would also point out that in suppurating hæmarthroses the inflammatory reaction of the synovia is relatively slight and in reality represents a mild type of suppurating synovitis. When a suppurating arthritis, such as above described, does not progress satisfactorily, usually because the operation has been done too late, synovectomy has been recommended, but I should advise you not to dally with this operation but to resort without delay to subperiosteal resection of the joint.

*Penetrating wounds of the knee with the projectile remaining in the joint.* First, as to the symptomatology of foreign bodies in the articulation when infection is absent, the patient apyretic and the knee-joint neither red nor markedly swollen, in other words, when there is no notable inflammatory reaction in the joint containing a bullet or bits of projectile. One is always dealing with a patient who is suffering with a joint immobilized in extension or in slight flexion and containing some fluid. The subjective

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symptom pain and the more or less evident objective symptom of an intra-articular fluid collection are constant. The most characteristic pain is that due to the wedging in of the projectile between the two bony planes. It may be continued and become intolerable when any movement is given to the joint. If the projectile is located under the edge of the patella the pressure of the finger over the projectile will cause a very localized intense pain. Localized pain on pressure has also been encountered when the projectile was interposed between the tibia and femoral condyles. It is a most constant symptom, very sharp and localized, increased by external pressure of the area of the projectile and by movements imparted to the joint. The intra-articular fluid collection is rarely absent, but the joint is enlarged, not because of œdema or lymphatic infiltration, but because there is a trauma of the component elements of the articulation and the fluid may be simply serous, occasionally seropurulent. This fluid, like all traumatic intra-articular collections, finally disappears under proper treatment or else it becomes secondarily infected. The diagnosis of the presence of a projectile in the joint is an easy matter when with the two above-mentioned symptoms there is a single aperture in the integuments and then a radiographic examination will locate the site of the foreign body. This should be done before any operation is undertaken.

Now, let us suppose that the patient is brought in with an enlarged knee presenting a single aperture and there is pyrexia. Let me say at once that an extra-articular foreign body may very well give rise to this clinical picture from the traumatism alone and cause a considerable intra-articular fluid collection, so that it would be a gross mistake to resort to arthrotomy at once before making a radiographic examination, since the removal of the projectile situated outside of the joint capsule is quite enough to cause all symptoms to subside and bring about a rapid recovery.

It is equally obvious that a joint may be opened and yet the projectile not be discovered, and it is likewise clear that the prognosis will be very different according to whether or not the projectile has been found and removed. Besides revealing the site of the projectile, radiography will show the bone lesions if any exist and, therefore, is a guide of the greatest importance as to the surgeon's conduct of the case.

I will first consider injuries of the knee-joint in which the projectile is free in the articular cavity. Clinically, you will find the knee enlarged, frequently larger and more inflamed than when there are two apertures. In the cases under consideration there is only the entrance wound, which will differ essentially in aspect according to the nature of the projectile. A rifle bullet, unless it ricochets, nearly always produces a punctiform entrance aperture, while a shrapnel ball gives rise to a somewhat larger entrance wound, but relatively circular in outline, while bits of bursting shell produce a stellate entrance wound which varies in dimensions according to the size of the projectile.

Since the nature of the foreign body plays an important part in penetrating wounds of the knee, it may perhaps be well to make a distinction

according to whether the projectile is a bullet, a shrapnel ball or a piece of bursting shell. Although rifle bullets have been, and to some extent still are, looked upon as aseptic foreign bodies, on account of their penetrating velocity, and although they do not usually carry any bits of clothing into the wound and occasionally appear to be fairly well tolerated by the joint, it is none the less true that their removal should be undertaken without delay. Shrapnel shot, which is larger than the small-bore bullet, is much less aseptic than the latter and always carries in bits of clothing along with it as it is most always deformed. For this reason, too, it produces contuse lesions of the soft capsular structures, and, therefore, as it is almost certain to set up infection in the joint, it should be extracted as soon as possible after the receipt of the injury. Bits of shell, on account of their sharp irregular edges, often from their size as well, the bits of clothing which they invariably carry into the wound and the severe lesions to the soft capsular structures that they produce, give rise to extremely serious infections which develop with great rapidity. Therefore, their early removal from the joint is imperative.

The foreign body having been exactly located by radiography or, more simply still, by a precise radioscopy, you will proceed to remove it. At one finger's breadth outside of and behind the cutaneous elevation at the external border of the patella and parallel to it, an incision is made whose upper angle reaches to within three fingers' breadth above a plane passing through the base of the patella. Below the incision extends to the level of the tuberosity of the tibia by giving it a slightly curved direction with its concavity looking slightly upward and inward. The skin having been incised you will have exposed the fleshy body of the vastus externus, at the upper part of the incision, while at its middle opposite the external border of the patella, is the outer wing of this bone, and, lastly, at the lower part one sees the external border of the ligamentum patellæ. Following the direction of the skin incision the capsule is opened beside the patella and the joint cavity is entered. The borders of the opening in the capsule are held with hæmostats and the incision is extended upward to the apex of the subquadriceps cul-de-sac, but in order to reach this point some of the fibres of the vastus externus must be cut. The capsular incision is next carried downward and thus the joint is completely opened by suppressing the upper and lower capsular culs-de-sac and an unobstructed view may be had of the articular ends. To facilitate the exploration of the bones of the joint, it is an easy matter to make an inward dislocation of the patella while the entire extent of the bone surfaces may be seen by making a latero-internal flexion of the leg. In some cases the projectile may be removed if it is free in the joint cavity, while if it is lodged in the bone it can be removed under the control of the sight. This technic does not mutilate the structures surrounding the patella, and later on, if considered feasible, resection of the bones can be done without resorting to complementary incisions. In other words, an arthrotomy carried as described can, in certain cases, be the first step in a resection of the joint. After



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removal of the projectile the joint is immobilized, as already described, in a posterior plaster case.

Let us now suppose that the projectile is lodged in the bone without fracture or fissure having taken place. This condition is sometimes met with. In these circumstances there is little difference in the operative technic from that just described, but when the foreign body is a shrapnel ball or a piece of exploded shell, the joint is usually, if not always, infected, and then I advise making the U-shaped incision in order to freely expose and drain the joint if resection is not deemed necessary.

*Penetrating wounds of the knee with bone lesions*, a condition that is the most frequent in the present war. These lesions are very serious on account of their evolution, and this fact has led many surgeons to resort to amputation at once, a practice which I most strongly condemn. Allow me to impress upon you that the bone lesions represent the only factor of gravity in these injuries. This notion is fundamental from the standpoint of treatment, and, as I shall endeavor to show, it is absolutely necessary for every surgeon to know, given the frequency of this class of penetrating wounds of the knee by projectiles of war. They may probably represent about 33 per cent. of wounds of the knee-joint treated at the front. This proportion may be reversed in the case of base hospitals. What is essential is not to underestimate the frequency of fractures of the epiphyses and the terrible consequences arising therefrom when the condition is overlooked. Indirect fractures are the result of intra-articular fissuring starting from the focus of fracture seated either in the tibial diaphysis or that of the femur. Direct fractures follow the traumatic action of the projectile, be it a bullet, shrapnel or a piece of bursting shell. These vulnerable agents are quite susceptible of giving rise to identical bone lesions regardless of their varied shapes and different velocities.

The bone involved may be the tibia, which is most exceptional, frequently the patella and still more frequently the lower end of the femur. In the latter case only one condyle may be involved, sometimes the lower end is smashed to bits so that it represents the true type of fracture with multiple fragments.

The projectile will be found either free in the joint cavity or embedded in the bone surface or medullary cavity.

Besides these principal lesions of the epiphyses, the occurrence of fissures in the diaphysis of the corresponding epiphyses must not be overlooked. The notion of these epiphyso-diaphysary fissures is of considerable importance in practice, as it gives the reason of failure in cases of delayed resection and explains the necessity of amputation. These fissures are the factors of osteomyelitis, an important cause for amputation in injuries of the knee-joint.

The surgeon will also have to deal in some severe injuries of the knee with lesions of the surrounding soft structures. There is frequently a formidable disproportion between the bone lesions and the outer aspect of the knee. A

projectile producing a small entrance aperture may work havoc in the bones of the joint and it is only by radiography that the real extent of the damage to the joint will be ascertained. Occasionally this examination will be insufficient, as it only reveals bone lesions of lesser importance. It is a demonstrated fact that no relation exists between the evolution and the degree of fracture and it is well known that serious complications can arise quite as well in cases where only one condyle is destroyed as when the entire epiphysis of the femur is involved. For this reason it is essential to exactly define the extent of the lesions, and this can only be obtained by taking radiographs in two different planes.

The clinical evolution of penetrating wounds of the knee-joint when only treated by arthrotomy is somewhat as follows: During the first four or five days following the interference, there is an exclusively local reaction in the joint, the temperature ranging between  $38^{\circ}$  and  $39^{\circ}$  C. or even higher. The important fact to be noted, however, is that although there will probably be *a decrease in the amount of suppuration, on the other hand you will discover that there is an increase in the size of the lower end of the femur and upper end of the tibia; the popliteal space becomes tumefied, an œdema, which progressively extends upward to the thigh or downward to the leg, appears, the inguinal lymph-nodes are greatly enlarged and the general condition of the patient becomes bad, assuming a typhoid state.*

Now, regardless of the absolute immobilization and complete rest of the joint, the patient will nevertheless complain of pain in the bones, spontaneous in character and which is characteristic of osteomyelitis. Such is the usual outcome of arthrotomy pure and simple done in cases of penetrating wounds of the knee-joint with bone lesions. Consequently, it is clear that arthrotomy is a useless operation in these circumstances, and, if the patient escapes with his life after amputation has been done, he does so with the loss of his limb.

The proper treatment of these cases when seen in time, that is to say, within the first thirty-six hours, perhaps two days, following the receipt of the injury, as is the case in the immense majority of them, is typical subperiosteal resection if the amount of damage done is not so considerable as to require more than the excision of 10 centimetres, as otherwise the resulting shortening would leave a useless limb. Of course, when the damage to the bone is too considerable, likewise that of the surrounding soft structures, with lesions of the popliteal vessels, amputation is the only recourse left to save the patient, and in order to be as economical as possible, *always perform circular amputation as low down on the thigh as possible and never suture the stump.* The further development of infection will thus be avoided.

What is the real value of arthrotomy in penetrating wounds of the knee-joint with bone lesions? In reply to this question I say without the slightest hesitation that it is devoid of any, and, whether done directly after the injury has been received or when done some time after, *arthrotomy will not prevent the nefarious evolution of infection and osteomyelitis, and in cases in which*

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*this operation has given good results the lesions were confined to the synovia and no damage done to the articular surfaces.*

Those surgeons who start with the erroneous idea that in order to cure a knee-joint in which the epiphyses are injured by the missile, it is enough to create free drainage of the pus, base their mistaken notion upon an inexact anatomical idea, namely, that any retention which may arise in the synovial cavity of the joint at its posterior aspect may be considerable, on account of the recumbent position of the patient; starting likewise from the erroneous pathologic standpoint that the posterior swelling is due to an intra-articular collection in retention, the consequence of this threefold erroneous interpretation of these injuries is that certain surgeons have devised arthrotomies with multiple or posterior incisions, all to no purpose, as can readily be surmised.

I am convinced that in this group of penetrating wounds of the knee-joint arthrotomy, no matter what technic may be followed, despite the most perfect immobilization and after-treatment, will never, under any conditions, cure the bone lesions. *Arthrotomy in these cases means an early amputation at the thigh!*

The only proper and, I may add, successful treatment of penetrating wounds of the knee with lesions of the bones is typical resection almost always, occasionally atypical. A comparison of the results obtained by other methods, a correct knowledge of the pathology and clinical evolution of these lesions, clearly reveal the value of this operation. What any surgeon of experience should know of the structure of the femoral and tibial epiphyses is in itself a sufficient explanation of the teachings I maintain. We know that the femoral and tibial epiphyses, as well as the patella, are constructed, from the architectural viewpoint, by osseous layers which are dovetailed together in both the transversal and vertical directions in order to form a spongy, areolar tissue. This spongy tissue is highly receptive to infection of any sort and the occurrence of osteosarcoma and tuberculous osteitis developing in the epiphyses of the femur is frequent. Therefore, one can readily understand how bacteria brought into the bone on the missile itself, but above all on the bits of clothing carried into the wound, find a particularly favorable soil for their rapid development, and those who are familiar with the extreme virulence of the infective agents in the surgery of warfare are fully aware of the particularly distinctive evolution of these bacteria in a soil well disposed for their reception.

On the other hand, in cases of fracture where there is little, if any, displacement of the fragment or fragments, infection will nevertheless travel by way of the anatomical communications uniting the spongy tissue of the epiphysis with that of the diaphysis and from here invades the medullary canal, and the outcome is an acute osteomyelitis of severe grade. When the epiphysis is broken into numerous fragments these become infected almost from the time of the receipt of the injury, as they are mostly cut off from their blood supply, and represent just so many septic foreign bodies. Therefore common sense dictates that these must be removed and that subperiosteal

resection is the only rational treatment in the class of injury under consideration.

To derive the greatest amount of good from subperiosteal resection of the knee-joint, the time at which it is undertaken is of capital moment.

If the operation is resorted to some time after the receipt of the injury, between ten and twenty days, or if the operation is done following a primary arthrotomy which, unfortunately, is not uncommonly the case, it may be termed a late resection.

Defined as above, late resection gives very bad results and is bound to give rise to disappointment and discredit this otherwise orthopædic and life-saving operation, which should be resorted to early during the first three, perhaps four, days following the receipt of the injury. Of course, it goes without saying that the anatomic diagnosis has first been made by means of radiography. The details of subperiosteal resection of the knee-joint will have to be reserved for later discussion.



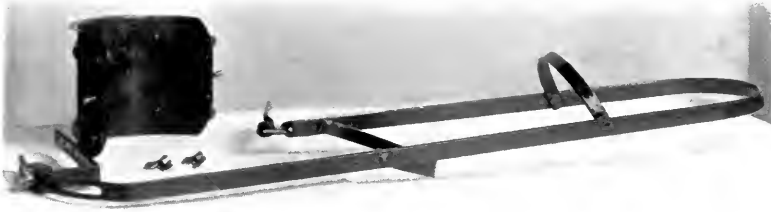


FIG. 1.



FIG. 2.



FIG. 3.

## APPARATUS FOR THE TREATMENT OF COMPOUND FRACTURES OF THE FOREARM

By H. T. BUCKNER, M.D.  
OF SEATTLE, WASH.

I WISH to present a new apparatus for the treatment of compound fractures of the forearm and compound fractures in and about the elbow joint.

The apparatus consists of two parts: A metal cuff that is well padded and strapped around the humerus and a metal frame that holds the forearm. The frame is made longer than the forearm in order that extension straps may be fastened to the forearm, and to the straps is fastened some rubber—that is, fastened to the cross-bar of the frame, thus permitting extension to be made upon the forearm if desired.

A piece of canton flannel or muslin may be folded over the longitudinal bars and pinned, making a soft hammock for the arm to rest in. If necessary for a little firmer support, a well-padded splint may be put in the hammock beneath the forearm.

The frame is made adjustable so that you can move the elbow a little when desired, as well as be able to dress the arm in the desired amount of flexion.

The frame is open, so the wounds are easily reached, and any method of sterilization of the wound can be used or carried out.

By turning the cuff over that fits around the humerus and by turning over the cross-bars, you can use it on the opposite side, thus making it suitable for either right or left arm.

The splint is light and can be made either of aluminum or iron.

The splint is an ambulatory one, and the patient can be up and around without retarding his recovery.

## A NEW INCISION FOR EXPOSURE OF THE LOWER ABDOMEN AND PELVIS

By JOHN W. CHURCHMAN, M.D.

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PROFESSOR OF SURGERY, YALE UNIVERSITY

THE incision here described was devised on account of my dissatisfaction with the exposure given by other incisions in operating on the rectum and on the pelvic ureter. It was first employed in an exploration of the abdomen for malignant disease of the rectum in which it was expected that a combined excision would have to be done and a good exposure of the deep portion of the pelvis would be needed. The rectal growth proved to be a melanotic sarcoma<sup>1</sup> and as there were multiple metastases in the liver no resection was made. The exposure of the left side of the pelvis was so excellent, however, and so superior to that obtained by the ordinary incisions—and this with little or no retraction—that I now regard it as the incision of choice when wide exposure in this part of the abdomen is necessary. No one who has operated on the common duct through a longitudinal incision and has compared the exposure thus obtained with that provided by a hockey-stick incision in which the *m. rectus abdominis* is divided transversely, can doubt the importance of good exposure; for with the latter incision a common duct operation can be properly done, while with the former the surgeon—working in the depths and requiring the constant tug of strong retraction—can do justice neither to himself nor to his patient.

In a similar way the incision here described gives excellent exposure of the whole lower abdomen and pelvis. The incision may be made on one side only (Plates I and II). Or, when wide exposure of the whole pelvis is needed (as, for example, in the case of large impacted myomata), the lateral oblique incision may be made on both sides (Plates III and IV); when this is done, the edges of the incision fall apart and little retraction is needed for the roomiest possible exposure.

The closure of the incision is by the fascial overlap method<sup>2</sup> and the abdominal wall is therefore left stronger than before operation. As the upper arm of the incision is made by splitting the *m. obliquus externus* in the direction of its fibres, the incision is well adapted for operations on the left colon and rectum, not only on account of the excellent exposure obtained, but also because of the fact that the ideal conditions are present for a colostomy, the muscle being closed about the bowel much as is done in a colostomy through a MacBurney incision.

The advantages of this incision over the Pfannenstiel are obvious. In

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<sup>1</sup> This I have reported elsewhere.

<sup>2</sup> Every abdominal incision should be closed by the fascial overlap method. particularly every midline incision; the occurrence of post-operative hernia in midline wounds is inexcusable and will be absolutely prevented if the fascia is overlapped.



# PLATE I

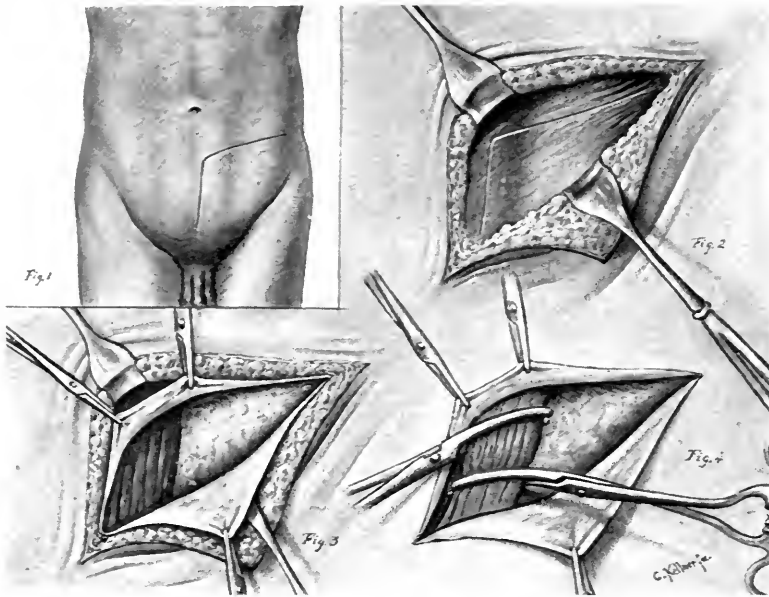


FIG. 1.—Skin incision.  
 FIG. 2.—Fascial incision (the horizontal arm should run exactly in the direction of the muscular fibres and not at slight variance with that direction, as shown in the illustration).  
 FIG. 3.—Fascial incision; rectus exposed, after reflection of fascial flaps.  
 FIG. 4.—Rectus grasped by clamps.

# PLATE II

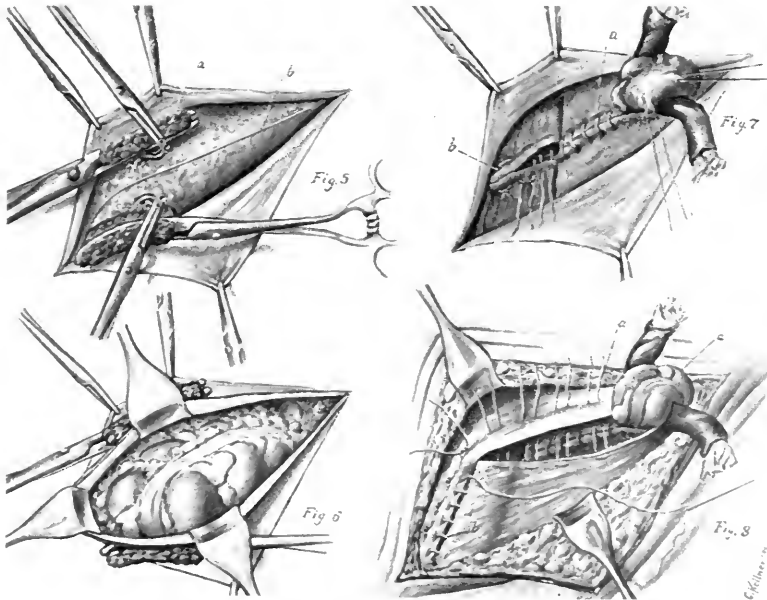
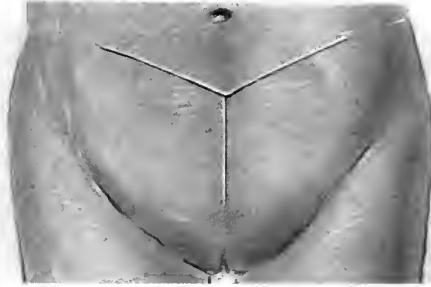


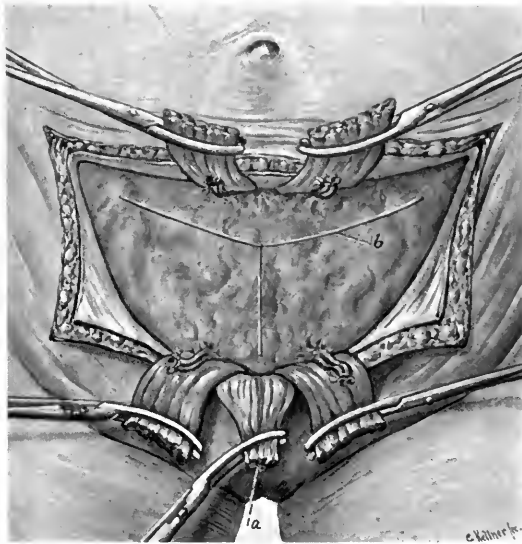
FIG. 5.—Rectus divided: *a*, epigastric vessels ligated; *b*, incision in transversalis fascia and peritoneum.  
 FIG. 6.—Exposure of peritoneal cavity.  
 FIG. 7.—Beginning of closure: *a*, continuous stitch in peritoneum and transversalis fascia; *b*, mattress sutures in rectus.  
 FIG. 8.—Closure continued: *a*, overlapping of anterior sheath and external oblique fascia by mattress sutures, and (*b*) suture of free edge; *c*, bowel left out for colostomy.

PLATE III



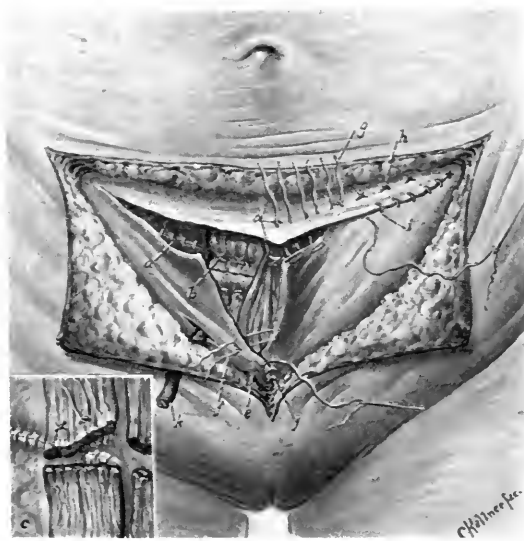
Bilateral incision in skin.

PLATE IV



Both recti and pyramidalis divided; epigastric vessels ligated; Y-shaped incision in transversalis fascia and peritoneum.

PLATE V



Closure of bilateral incision: *a*, running stitch in peritoneum; *b*, divided recti tacked to underlying fascia by mattress sutures (detail shown in *c*); *d*, pyramidalis tacked to under surface anterior sheath; *e* and *f*, overlapping by mattress sutures of anterior sheath and (*g* and *h*) external oblique fascia; *j*, suturing of free edge of anterior sheath and (*i*) external oblique fascia; *k*, drain.



## EXPOSURE OF THE LOWER ABDOMEN

the Pfannenstiel incision the abdominal wall is divided transversely *at one level*; my incision begins at the symphysis pubis and ends at the level of the anterior superior spine (or higher if one wishes). The recti muscles are then divided transversely. Both the lower and upper portions of the pelvis are therefore exposed at the same time: a point of great importance in operations on the rectum and on the ureter, or in extensive transperitoneal resections of the bladder.

The technic of the unilateral incision is well shown in Plates I and II, and needs only a few words of description.

1. *Skin incision* (Plate I, Fig. 1) begins at the symphysis pubis, runs in the mid-line upward for about two inches, then diagonally upward and outward toward the anterior superior spine. The point at which the longitudinal incision becomes oblique may be higher or lower, according as the chief exposure desired is the upper or lower part of the pelvis.

2. *Fascial incision* (Plate I, Figs. 2 and 3) repeats the direction of the skin incision, dividing the rectus sheath longitudinally, then crossing obliquely the anterior sheath and dividing the fascia of m. obliquus externus in the direction of its fibres<sup>3</sup> and as high toward the anterior superior spine as desired. It is of great importance, in operating on the bladder, that the anterior sheath of the rectus be divided down to the bone at the symphysis pubis.

3. *Muscle incision* (Plate I, Figs. 3 and 4; Plate II, Fig. 5).—The rectus muscle, thus exposed, is freed and divided between clamps. Care is taken to push back the epigastric vessels from the posterior surface of the muscle, clamp, divide and ligate them separately (Plate II, Fig. 5, *a*).

4. The fascia of the m. transversalis and m. obliquus internus and the peritoneum are divided by an incision which repeats the direction of the skin incision (Plate II, Fig. 5, *b*).

5. The exposure thus obtained, practically without retraction, is shown in Plate II, Fig. 6.

*Closure: a.* The peritoneum (with transversalis and internal oblique fascia) is sutured by a running stitch (Plate II, Fig. 7, *a*).

*b. Muscle.*—The divided rectus muscle may be approximated by mattress sutures (Plate II, Fig. 7, *b*). No effort at *accurate* approximation should be made nor should the stitches be drawn as tightly as shown in the illustration. The stitches do not hold well if the muscles—as is likely to be the case—are at all flabby. When there is any difficulty about bringing the cut ends together, they may be tacked to the underlying fascia as shown in Plate V, *b* and *c*; in this way the ends may be easily approximated. A good approximation of the rectus muscle is not necessary; the strength of the abdominal wall depends on the careful closure of the fascia and that is done on the principle which governs the radical cure of hernia.

*c.* The anterior sheath of the rectus and fascia of the m. obliquus externus (Plate II, Fig. 8) are closed by the overlapping method used in the radical cure of hernia, a flat overlap being obtained by one layer of

<sup>3</sup> The incision should be made *absolutely* in the direction of the fibres and not (as shown in the illustration) slightly at variance with that direction.

mattress sutures (Plate II, Fig. 8, *a*), and a second layer which tacks down the free edge (Plate II, Fig. 8, *b*). In the illustration space has been left for a colostomy (Plate II, Fig. 8, *c*) to illustrate that this may readily be done in cases where a colostomy is to be performed.

*d.* The skin is closed by a running stitch.

If exposure of the whole pelvis, rather than of only one side, is desired the incision is made on the principles just described, but the oblique arms pass to *both* sides from the mid-line as is shown in Plates III, IV, and V. After division of the anterior sheath and fascia of the *m. obliquus externus* and of the rectus muscle on both sides, the edges of the incision fall apart. The incision in posterior sheath and peritoneum repeats the direction of the skin incision (Plate IV, *b*). A wide semilunar opening is then present in the abdominal wall, and the whole lower abdomen and pelvis are exposed practically without retraction (Plate IV). In this patient a well developed *m. pyramidalis* was present and is shown divided across (Plate IV, *a*). I have been struck by the unusually easy convalescence, so far as abdominal pain is concerned, of patients in whom this incision has been used and it has occurred to me that the slight amount of retraction needed may account for their comfort.

The closure, when the incision is made on both sides, is identical in principle with that done when a unilateral incision is made. The steps are shown in Plate V. The peritoneum has been closed with a running stitch (Plate V, *a*), the recti tacked to the underlying fascia with mattress stitches (Plate V, *b* and *c*), the *m. pyramidalis* has been tacked to the under surface of the anterior sheath of the rectus (Plate V, *d*), mattress stitches overlapping the anterior sheath (Plate V, *e* and *f*) and the fascia of the external oblique (Plate V, *g* and *h*) have been placed. A running stitch is tacking down the free edge of external oblique fascia (Plate V, *i*) and the anterior sheath of the rectus (Plate V, *j*). It is probably a wise precaution, and in no way complicates matters, to insert a small drain for serum through skin and sheath down to the intermuscular space (Plate V, *k*); this I always do in operating for umbilical hernia, in which a closure is made similar in principle to the one here described.

The fear of dividing the rectus muscle transversely which haunted all surgeons for years, and still haunts some, is it seems to me entirely unwarranted. It is true that it is impossible accurately to approximate the edges of the muscle so divided; but the union of the cut edges with fibrous tissue provides a perfectly good functional result. Nor is the fear that injury of the nerve supply of the muscle will increase the liability to hernia justified. The strong closure of the abdominal wall is a question of structure and not of function; if the fascia be properly closed, hernia will not occur no matter what the condition of the muscle. I have often deliberately divided (in inguinal hernia done under local anæsthesia) the ilio-hypogastric and ilio-inguinal nerves without jeopardizing the result; and to explain the recurrence of a hernia by nerve division is to overlook the real cause which was faulty closure.

## ABDOMINAL WOUND TECHNIC

By JOHN O'CONOR, M.D.

OF BUENOS AIRES

SENIOR MEDICAL OFFICER OF THE BRITISH HOSPITAL AT BUENOS AIRES

I ASSUME that my experience is not unique when I state, that, although over ninety per cent. of wounds which are aseptic prior to operation remain so afterwards, there is still quite a percentage in which we find that the wound which appears perfect on the sixth day is converted into a leaking puddle of blood and peptonizing fat by the twelfth. In other words, a modern aseptic wound does not necessarily imply a good physiological one.

The object of this communication is to endeavor to draw these two factors more into line. And it is my belief that the solution of the problem can be found in our paying more acute attention to hæmostatic details and to the elimination of dead spaces.

The vital essential in the treatment of any wound is hæmostasis, and I have no hesitation in stating that the surgeon who ties most bleeding vessels gets the best results, and as my teacher, the late Sir Charles Ball, used to say "sleeps better the night after." Prompt and permanent stemming of the crimson tide is our most valuable asset, it makes surgery possible, it favors repair, it obviates sepsis, it prevents shock, and it saves life.

The details which I am about to mention may appear very trivial, but when added together may help to encourage method on which operative efficiency largely depends.

In most operations on the abdominal wall, inguinal hernia in particular, one has frequently to forceps ten or twelve vessels, half of which may be seized accurately, the other half have to be caught up with some surrounding tissue, yet the method of ligation is absolutely different in each variety. In the former the forceps must not be unlocked until the knot is tied, and ends of ligature cut away, otherwise slips and blanks ensue.

In the latter, bleeding will continue if the forceps are not unlocked before the knot is completed, as the interposition of the forceps head and extra tissue, in mass, acts as a buffer, and prevents the final snap of the ligature which is necessary for the effective constriction of the bleeding vessel. And it may be well to remember that gentle torsion is, at times, a useful preliminary to prepare the way for the ligature of small vessels, difficult to isolate, in connective tissue. Again, it is extraordinary how few understand the simple art of swabbing a bleeding wound, nine assistants out of ten, when told to "dry," will apply the mop with a jerky horizontal wipe instead of with a steady vertical dab, the result being, that ligatures are frequently brushed off as quickly as they are applied. There is another matter which demands serious attention—the planning of our lines of incision so as to avoid tapping important vessels during the course of an

operation; injuries with the knife can be easily controlled in daylight, but a puncture with a needle often proves to be the Devil in the dark. And I do not know of any operation in which there is greater likelihood of meeting with the latter than in the present fashionable vertical lateral incision for removal of the appendix, and I can personally bear witness to the facility with which a deep epigastric vessel may be speared when suturing the wound. *En passant*, I have for this reason recently reverted to the McBurney incision, when same is pathologically feasible. Also, it is well to bear in mind that hemorrhage which spontaneously ceases after exposure to air, or during the course of the operation, may be a very elusive quantity, in that the temporary fall of blood-pressure frequently induces a false hæmostasis in small cut vessels, but afterwards, when the patient is warmed up in bed, and reaction takes place, there is every likelihood that some bleeding will recur, particularly as the unligatured vessels are constantly stimulated by the involuntary jactations of a semiconscious patient.

May I add that ligation is the only method of stasis in which I have any confidence, and its value may be considerably enhanced by a good closure suture which keeps the respective wound structures in firm apposition.

The success of the technic of wounds is so absolutely dependent on the preliminary preparation of the patient's skin that it would be puerile to omit mention of the latter when describing the principal details of the former. For many years, my rule has been, on the evening prior to operation, to have the part shaved, scrubbed with nail-brush, soap, and hot water, well washed with alcohol mercurial lotion (hyd. perch. 1, acid. tart. 5, water 200, alcohol 800), and then covered with sterilized lint soaked in mercurial lotion (hydr. perch. 1, acid. tart. 5, water 2000), sterilized wool and bandage. This dressing is not removed until the patient reaches the operating table on the following day, when a final washing with alcohol mercurial lotion is done, before the field is isolated with dry sterilized towels. Some few years ago we were all suddenly overcome with the comparative simplicity and efficiency of the iodine method, and after its employment in hundreds of cases, I have much to say in its favor, particularly for accident and emergency work where rapidity is a necessity. Also, it is beyond all question that in operations on the suspect nether regions, tincture of iodine acts extraordinarily well. But, like everything else in life, it must have some compensatory defect, and I must acknowledge that I have suffered more with serious intestinal adhesions during the past three years of iodine treatment than in the previous three and twenty with the above-mentioned mercurial one. This has been particularly accentuated in cases in which some extrusion of bowel was an operative necessity, such as posterior gastro-enterostomy, ileocolostomy, etc. Consequently, I have to endorse what has been recently reported elsewhere—iodine is a dangerous peritoneal irritant. During the past few months I have gone back to the old method for ordinary abdominal work.

Irrespective of the particular method employed in disinfecting the skin,



I think that it is essential to adopt some plan for the complete isolation of skin and exposed layers of parietal wall from the operative field. This I find can be easily accomplished by utilizing Mr. Marmaduke Shields' method of holding the abdominal wall together in prolonged operations. Years ago he recommended that a few through-and-through silk sutures should be passed through each parietal wall before commencing internal manipulation, so as to prevent subsequent separation of the parietal strata, and so reduce the chances of infection and the probability of defective repair ensuing in structures which are often, unnecessarily, mutilated during a protracted operation. He, at the same time, suggested that the ends of such sutures, if grasped in forceps, provided very convenient retractors. These excellent practical suggestions may be amplified by placing a small towel of fine texture, with a slit in centre (corresponding to length of wound) around area of incision, two through-and-through strong silk sutures are passed, on each side respectively, embracing peritoneum, muscular wall, skin and towel (passing on each side about one inch external to the edge of slit in latter). When these sutures are tied, the included fringe of towel drops down to level of peritoneum, and forms a fixed curtain which completely excludes the exposed surface of the parietal wound, and the large superficial portion of towel completely occludes the underlying skin in the operative zone.

Thus the possibility of peritoneal irritation, from contact with skin, is eliminated, infection of parietal wound from intestinal leakage is avoided, and the parietal layers being held in position obviates fumbling about, at the conclusion of the operation, in search of a retracted edge of peritoneum or rectus sheath.

It is unnecessary to add that when the intraperitoneal work is finished, the shield stitches and towel are removed, and closure is effected by continuous catgut tier sutures.

*The Closure of Wound.*—There are some structures in the abdominal wall which do not always receive the amount of suturing attention which they deserve, viz.: the posterior lamina of rectus sheath (in upper mesial segment), the transversalis fascia generally, and the subcutaneous fatty layer (which, by the way, contains most of the wounded blood-vessels) in particular. Commencing with the continuous suture of peritoneum, I recommend the practice of catching up the corresponding edge of posterior lamina, or transversalis fascia, in each stitch, in order to obtain some point *d'appui* for the firm closure of peritoneum, which is often very fragile and holes readily form, which, if undetected or neglected, afford an ideal lie for an omental or intestinal adhesion and an excellent tee for a subsequent ventral protrusion. Moreover, the cultivation of the habit prevents one forgetting, at the fatigue stage of the operation, the anatomical existence of a posterior rectus sheath or a transversalis fascia: both in their respective sphere are useful, indeed necessary, adjuncts to the normal restoration of the parts.

*The Subcutaneous Layer.*—Accurate approximation, by suture, of the subcutaneous fatty tissue is the best preventive against the formation of

a dead space in which stagnant blood is most likely to accumulate—blood which very soon becomes converted into disintegrating toxic fibrinous material, which frequently serves as an ideal medium for the cultivation of pathogenic germs, which always protracts convalescence, which attenuates the underlying line of tier suture and so favors the formation of subsequent ventral hernia, which affords the pabulum for that most annoying and compromising circulatory condition, femoral phlebitis, and which occasionally allows a deadly missile, a flat globule or clot, to gain entrance to an open vein, and find its billet in the pulmonary artery. I have met them all—every thing will happen to a surgeon if he will only live long enough.

It may be alleged that if the tier method of suture were abandoned, and we reverted to the old "through-and-through," dead spaces would be avoided. This is, to a certain extent, correct, but it possesses some distinct drawbacks. To be effective it must possess some tension, which is almost impossible to graduate, and which, very often, proves detrimental to the vitality of the structures encompassed in its grasp. And its insertion entails the employment of a large needle, which is driven out of hæmostatic range, oftentimes wounding deep-seated hidden vessels, with resulting deep-seated hidden hæmatomata, which may be even more dangerous (phlebitis and embolism) than the existence of a subcutaneous swamp, which is readily exposed. It, moreover, seriously compromises the future function of the muscles and nerves within its ambient. Notwithstanding such disadvantages, I consider it to be the lesser of evils, in septic cases, as it would be fatuous to bury continuous layers of any suture in the parietal wall in the presence of virulent infection. However, in such instances, it is my custom to employ as few sutures as possible, with the minimum of tension, always in association with large tubes, which serve a double purpose—drain both abdomen and abdominal wall.

I have oftentimes employed a combination of both, continuous catgut suture of peritoneum and rectus sheaths, and interrupted silkworm-gut sutures to close, in mass, the subcutaneous layer and skin. I have seen many excellent results follow this practice, but it has, like the above-mentioned one, to be frequently supplemented with some superficial sutures so as to accurately approximate the edges of skin wound. I find that the skin, subcutaneous wall and subcutaneous floor (ant. lamina of rectus sheath or external oblique as the site may be) are, respectively, more effectively and expeditiously united by employing a form of continuous catgut suture which we term the Gallo stitch (Fig. 1). And in order to exclude ambiguity, it is only necessary to remember that the needle, in transit through above structures, always passes away from the operator, viz.: from proximal to distal side of wound. Commencing at one angle of the wound, a needle, with a long strand of strong catgut attached, is passed solely through skin and close (2 mm.) to edge of same on each side, and suture tied. The needle is then passed through skin (proximal side) at a point about 13 mm. from the edge of wound, traverses the whole depth of proximal wall, then catches

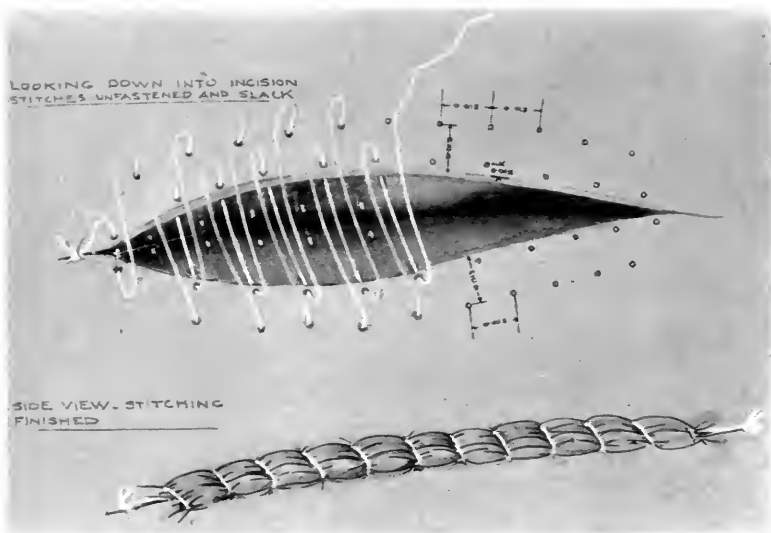


FIG. 1.—The "Gallo" stitch for closing abdominal wounds.



## ABDOMINAL WOUND TECHNIC

up a few fibres in centre of floor, reënters on this level and passes from within outward through the distal wall at a corresponding point on skin 13 mm. from distal edge. The needle is next carried back across wound, and enters skin 2 mm. from proximal edge, passes again over wound and is made to emerge through skin 2 mm. from distal margin. In this manner continuous alternate deep and superficial sutures are applied until the whole wound is closed. Then the efficacy of this suture, for approximation purposes, is tested by folding up a bibule, and rolling same, with firm pressure, from one end of wound to the other. If blood escapes in the last roll the suture is defective—so far I have not seen an instance of it. I may mention that I have frequently applied this test for needle bleeding and ligature slipping hemorrhage to the other forms of continuous sutures depicted in text-books, and have invariably found positive evidence of this insidious, invisible, and, oftentimes, pernicious type of hemorrhage following the closure of wounds which appeared perfectly dry before the introduction of sutures.

Some years ago I tried a similar method of suture, using silk, but found that the resulting tension was inimical to aseptic union. The extra resiliency and gradual absorption of catgut probably explains the difference in results. In dozens of cases in which this suture has been employed there has not been a single instance of subsequent skin necrosis, sepsis, or subcutaneous collection of serum, and all have healed by physiological first intention. There is, on insertion, some slight puckering (never infolding) of skin along suture line, which disappears in a few days. And the suture is removed by the natural process of absorption in the third week. This suture may be briefly described as a continuous one, approximating alternately (1) the mere edges of skin, and (2) the skin, subcutaneous layer, plus a chip of underlying floor.

As it is obvious that the success attending such a method of suture greatly depends on the nature and sterility of the suture material itself, it is essential when advocating sole employment of catgut, both as ligature and suture in aseptic abdominal wounds, not to ignore the ominous fact that catgut has almost rivalled eczema in the number of methods advocated, from time to time, for its "cure." And probably this was one of the reasons which induced Sir John Bland Sutton to state that "there were more people done to death annually by catgut, under the name of surgery, than by a hemp rope, under the name of justice." I confess, at the time, I thought that he exaggerated its lethal powers, but some years later this opinion was shaken by the personal experience of two deaths from tetanus, within twelve months, following the one operation, above all others, in which the greatest anti-septic precautions are taken—simple radical cure of inguinal hernia, in which catgut is always used in quantity. (These two instances constitute my total experience of tetanus under such conditions.)

Although a subsequent laboratory inquisition (including rats) on our stock of catgut returned a verdict of "not proven," the phenomenon demanded change of some sort; all known methods, including Lister's and

Macewen's, were jettisonized, and the one which I am about to describe substituted.

I wish here to thank the hospital pharmacist, Señor Paola, for his most patient and valuable assistance and suggestions during the various experiments which led up to a standard result.

(1) Raw catgut, free from fat, as supplied by surgical stores, is wound into loose rolls and placed in a Mayo Robson's or Jellett's bomb, which is almost filled with a mixture of equal parts of ether and alcohol, and boiled for half to one hour (according to size of catgut) in a kettle of boiling water.

(2) The catgut is then removed, with sterilized forceps, and placed in a solution of alcohol 90 per cent. and formalin (40 per cent. strength) 10 per cent.

It is retained in this mixture for forty-eight hours.

(3) It is then immersed and washed in a small basin of ether for half to one hour, according to size.

(4) And finally, stored in glass bottles filled with equal parts of ether and alcohol until required for use.

This catgut has been tested in the independent government laboratory, and reported to be absolutely sterile, and I can clinically guarantee that it is an ideal suture material, clean, tensile, non-irritant, and amply durable (ten to twenty days). And, moreover, is extraordinarily resistant to external infection, as proved by its service in cases of circumcision, hemorrhoids, colporrhaphy, etc.

This thesis would probably be incomplete without some reference as to how I disinfect my hands, irrespective of the use of dry heat sterilized rubber gloves for operation. After a liberal use of nail scissors, the hands and forearms are scrubbed, for five minutes, with nail brush and soap in a running stream of hot water. Then washed in a hot watery solution of formalin (1 in 200). Next submerged, for a few minutes, in alcoholic mercurial lotion (1 in 1000) and just preceding, and during, operation rinsed in a basin of mercurial lotion (1 in 2000).

As post-operative sepsis, like the zero in roulette, will probably give a 1 in 37 ratio, it may be apropos to mention that when it turns up, the wound is at once laid freely open, irrigated with hot peroxide lotion (60-120 c.c. to litre), immediately followed by hot carbolic lotion (15 c.c. to litre), and a hot mercurial fomentation, wrung dry, applied.

This formula is repeated three times daily until the wound becomes aseptic, when it is united by a few catgut sutures, or drawn together by strapping. As I never bury unabsorbable sutures or ligatures in the abdominal wall, the septic process is usually of short duration.

Finally, as to after-treatment, I have only one suggestion to make, keep the part at rest for fourteen days, as this was taught in Trinity College to be the minimum time necessary for the physiological *restitutio ad integrum* of any solution of continuity of body tissue. It is a practice in which I have the most profound belief.

## RESECTION OF THE LARGE BOWEL AT THE RECTOSIGMOIDAL JUNCTION\*

BY STANLEY STILLMAN, M.D.  
OF SAN FRANCISCO, CAL.

RESECTION of portions of the large bowel, or even the whole of it, is accomplished to-day without particular difficulty and in accordance with well-recognized principles: the same is true of the rectum, but it is occasionally one's fortune or misfortune to encounter an obstruction or disease of the large bowel which involves both the rectum and the sigmoid and for which resection is required. It is not necessary to enlarge on the technical difficulties encountered in performing a resection of this portion of the bowel and making an anastomosis below the brim of the pelvis, when the bowels are distended as the result of complete or incomplete obstruction. They are such, however, that one usually resorts to colostomy at once and reserves the resection and anastomosis for a later operation. Yet this very distention of the bowel may be utilized, except in extreme cases, and both resection and anastomosis done in the limited time permitted by the patient's condition at the time.

In most cases carcinoma in this situation is the condition necessitating the operation, but I have been obliged to do it for perforation of the sigmoid at this point, the result of a false diverticulitis, and another time for obstruction following dense adhesions at this point, the result of a previous pelvic operation.

Whether the method, to be described, of dealing with it has the merit of novelty or not, I am unaware, but it has proven singularly successful in my hands, and if it has not this merit it certainly has others to which I wish to subscribe. It is practically the same method that I have used successfully a few times in cases of cancer of the rectum proper, when the external sphincter could be preserved.

In those cases in which the location of the growth or obstruction can be determined beforehand, and in which the obstruction is practically complete, the sphincter should be stretched and the rectum thoroughly washed out and lightly packed with a strip of gauze before the abdomen is opened. In other cases this should not be done till after the abdomen has been opened and a clamp applied to the sigmoid above the point of section after milking back the contents.

The next step is the section of the sigmoid above the obstruction and invagination of the proximal end by means of a purse-string suture of Pagenstecher, the ends of which are left long, after which the clamp is removed, and the sigmoid mobilized sufficiently by ligation of its mesentery, if necessary to reach well below the line of section of the rectum. It is then kept out

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\* Read before the American Surgical Association, June 1, 1917.

of the way by pads till the resection of the involved bowel is completed. The section through the rectum is made after steadying and keeping apart its walls by means of several stay sutures passed through its peritoneal coat below and close to the line of section. With the proper distribution of pads and the exercise of a little care and ingenuity in controlling the escape of blood and intestinal contents, both these lines of section and the removal of the involved bowel can be accomplished with a minimum of soiling. The packing is now withdrawn from the rectum through the anus, and if desired, several strips may be drawn through the anus from above by attaching them together with sutures. After hemorrhage is arrested the exposed mucous membrane of the upper part of the rectum is wiped clean with moist sponges and painted with iodine for a distance of two or three inches, being held open all this time by the traction sutures.

With a little care and a pair of Mayo scissors and forceps, the mucosa can now be removed for an inch down the rectum, or more if possible, and the hemorrhage arrested without the use of ligatures, if possible. The end of the purse-string suture closing the end of the sigmoid is now attached to a thread previously fastened to the last strip of gauze drawn through the anus and, by traction in this by an assistant aided by a hand in the pelvis, the sigmoid is drawn well into the rectum. The suture is passed through the skin outside the anus and tied so as to fix the end of the sigmoid, but not to pull too much on it. Eight or ten sutures are now applied approximating the upper edge of the rectum to the surface of the sigmoid. If the patient is a woman, a dressed tube is passed through a counter opening into the vagina, or if a man, is brought out below the tip of the coccyx and the abdomen closed. Finally a large tube is placed in the anus.

The closed end of the sigmoid sometimes opens spontaneously, but usually requires opening with a knife or scissors through a speculum.

If the general condition of the patient permits, I prefer not to open it for four or five days, even though the patient may suffer some from symptoms of obstruction of the bowel. This procedure was followed by me first, a number of years ago, as an emergency one in a case of complete intestinal obstruction and was so successful that I have employed it since as the method of choice. I think the essential thing for its success is the distention of the closed sigmoid with gas or fluid which keeps the peritoneal surface of the sigmoid in contact with the raw surface of the rectum long enough for firm adhesions to form—secretions or blood are not confined between the surfaces, but can escape into the rectum freely. In the same procedure—applied to cancer of the rectum proper—the protruding sigmoid generally sloughs to a considerable extent within and even above the sphincter, though its blood supply may seem good at the time. I have not seen this happen in the higher operation, for the sigmoid does not have to be freed so much that its blood supply need be jeopardized at all, or at any rate, not so much that it cannot stand the distention.

In those cases in which the obstruction is complete and of such long



## LOW RESECTION OF LARGE BOWEL

standing that the sigmoid is enormously distended, the condition of the patient may be such that immediate colostomy is necessary. In this event, after the colostomy, there is time and opportunity for preparation of the bowel above and below the obstruction, and either end-to-end suture or implantation may perhaps be safely done, but I have had no more trying, difficult, tedious and uncertain work to do than this within the abdomen. While I am a sincere advocate of two-stage operations in general, when the indications are clear, I am quite the contrary, otherwise, and much prefer to take some chances and avoid two operations if possible. Particularly do I feel averse to a temporary colostomy, and rarely have done one without first opening the abdomen in the midline to see if it could not be avoided.

In case of disease or obstruction of the large bowel at the location under consideration, the procedure above given, so far as my knowledge goes, is the only one that gives a reasonable chance of success without a preliminary colostomy. As a matter of fact, it is comparable to a two-stage colostomy into the rectum. The procedure in question can be done as rapidly as an ordinary lateral anastomosis in a more favorable situation and without much more danger of infection than the first step of a colostomy. Of 8 cases in which I have followed this procedure, 1 died from peritonitis, the result, I think, of the spontaneous opening of the sigmoid on the second day. In 2 cases, one a man and the other a woman, there was fecal discharge through the drainage tube, in one quite profuse, but in both cases the fistulæ healed spontaneously in a few weeks. The portion of the sigmoid projecting into the rectum contracts and in some cases subsequent dilatation is required. The fact that both sigmoid and rectum are dilated while adhesion is taking place may explain why no difficulty has been observed from stenosis at the line of union as is usual in resection of the rectum with end-to-end suture through Kraske's incision.

In 6 of the cases the operation was done for cancer. In 1 of these in which the sigmoid alone was involved in the growth, there was no recurrence after three years. Of 2 in which both rectum and sigmoid were involved, in one there is no evidence of recurrence after six months. The other was living and free from recurrence five years after operation when last seen. One patient died after a year of pneumonia. In this case both rectum and sigmoid were involved, but there was no evidence of either local or general recurrence three months before death when last seen. The other 2 in which both rectum and sigmoid were involved, died within a year of local and general carcinosis.

### RECORD OF CASES

CASE I.—Operation at City and County Hospital. Records destroyed in fire of 1906. Patient was a woman with obstruction of the bowels with moderate distention, but without acute symptoms. A mid-line incision was made and the obstruction was found due to an annular carcinoma of the sigmoid just above brim of the pelvis. In the manipulation the gut separated in the middle of the constriction

without leakage from either end. A clamp was immediately applied to sigmoid and its mesentery ligated sufficiently to permit of resection above the growth and closure of its end with double row of sutures; the intention being to do a lateral anastomosis of sigmoid to the anterior wall of the rectum. The portion of the growth remaining was then removed, the line of section through the rectum passing below the brim of the pelvis. While endeavoring to close the end of the rectum before making the anastomosis the patient's condition became bad and great difficulty was experienced in keeping the bowels out of the way. In desperation I abandoned the plan of anastomosis and rapidly removed the mucosa from the upper part of the rectum, slipped the sutured end of the sigmoid into it, removed the clamp and sutured the edge of the raw surface of the rectum to the sigmoid with catgut sutures. An opening in the vault of the vagina was then made and iodoform gauze drains inserted, passing to each side of the rectum below the suture line. She did not suffer from the continued intestinal obstruction and after several days the closed end of the sigmoid gave way spontaneously, which was fortunate, as it was beyond the reach of my finger or vision with the specula we then had. There was no fecal discharge following removal of the drain. Nine months or so later she was without signs of recurrence, but was reported a few months later to have died of pneumonia.

CASE II.—Miss D., Lane Hospital, January, 1900. Operation for chronic obstruction of the bowels. Obstruction was found to be due to a small tumor of the sigmoid so close to the brim of the pelvis that in excising it an inch or more of the rectum had to be removed. Many mesentery glands were enlarged and several were included in the meso-sigmoid removed with the tumor. It was decided to try the same procedure described under Case I. The obstruction was not so great as to prevent the bowels being thoroughly cleaned out previous to operation. Previous to doing the resection the sphincter was stretched and the rectum washed out through a speculum and packed with gauze. The sutured end of the sigmoid was drawn in to the denuded rectum by a stay suture which was fastened to the skin outside of the anus. The sigmoid opened spontaneously on the sixth day. There was no fecal discharge after removing the drain. The pathological report was typical adenocarcinoma, but the enlarged glands showed no metastases. The patient was in good health three years later when last seen.

CASE III.—Mrs. S., Lane Hospital, July, 1900. Admitted with symptoms of acute intestinal obstruction. There was a previous history of pelvic pain and intestinal cramp. Pelvic examination disclosed tender masses in both ovarian regions. Mid-line incision. There was free peritoneal fluid and the pelvis was full of adhesions. The right tube was greatly enlarged and thickened and both ovaries enlarged. Adhesions were dense and much sharp dissection required. The obstruction was found due to angulation and adhesion of the small bowel. In removing right tube and ovary rectum was torn open at brim of pelvis and suture of the opening was not possible on account of rigidity and œdema of the rectal wall. It was finally decided to repeat the operation

## LOW RESECTION OF LARGE BOWEL

described in Case I. Numerous high enemata had been given before operation in the hope of relieving the obstruction, so both rectum and sigmoid were empty. Section of the sigmoid was made at a point where its walls were normal and section of the rectum was some distance below the brim of the pelvis. Rectal mucosa was removed and the closed end of the sigmoid was drawn into the rectum by a suture passed through the stump of its mesentery and fastened to the skin outside of the anus. On the fourth day the bowel opened spontaneously and on removal of the drain from the vagina the following day pieces came through the opening. A tubular drain was inserted in the drainage opening and sutured to the vagina. The sphincter was stretched and a large tube left in the anus. The discharge from the regina continued for several weeks and then ceased and the drain was removed. The patient was discharged and disappeared from observation. Microscopical examination of the removed tube showed many tubercles in its mucosa, but there were none noticed in the peritoneum at operation.

CASE IV.—Mr. A. I. O., Lane Hospital, May, 1903. Carcinoma of the rectum just palpable by tip of finger when patient strained. Abdominal incision. Large tumor at brim of pelvis involving both rectum and sigmoid. Resection of tumor and implantation of closed sigmoid into denuded rectum. The protruding end of the sigmoid could be felt in the rectum and was opened with a scalpel on the fourth day on account of general abdominal distention and vomiting. No fecal discharge on removal of drain. Patient left the hospital on the twenty-seventh day. Pathological report: Alveolar carcinoma. Patient died the following year from both local and general recurrence.

CASE V.—Mrs. C. H., Lane Hospital, September, 1903. Patient came for relief of hemorrhoids. Examination showed blood and mucus coming from high up the rectum, but no growth could be felt or seen by the speculum. There were no symptoms of obstruction of the bowels. Abdominal incision disclosed a hard mass in the wall of the rectum at the junction of the sigmoid. Resection of involved rectum and sigmoid and invagination of the sutured end of the sigmoid as described in Case I. Removal of vaginal drain followed by fecal discharge lasting for four weeks. Patient died a year later from general carcinosis.

CASE VI.—City and County Hospital. Records lost in the fire of 1906. Patient was a heavy man operated on for what was supposed to be appendicitis. The greatest tenderness was near the mid-line and under the anæsthetic an ill-defined mass could be made out by rectal examination. A mid-line incision was made and the mass found to have no connection with the appendix, but due to a small abscess between the sigmoid and rectum near the brim of the pelvis. There was an opening into the sigmoid communicating with the abscess and the case was regarded as one of cancer with spontaneous perforation. Involved sigmoid and rectum were removed and the closed end of the sigmoid pulled into the denuded rectum as previously described. The rectal wall was œdematous and rigid at the point of section and bleeding was serious. On the second day after operation fæces came through the rectum and the man died of peritonitis from fæces escaping into the

pelvis. The mass proved to be inflammatory and I have since concluded that it was a case of false diverticulitis, condition of which I was ignorant at the time.

CASE VII.—Mr. H. A. S., Lane Hospital, October, 1909. Growth in the rectum beyond reach of finger but visible with proctoscope. Abdominal incision. Tumor of upper part of rectum was found involving the sigmoid. Resection included upper part of rectum and lower part of sigmoid. Denudation of rectum and invagination of closed end of sigmoid was done. Drainage inserted through counter-opening at tip of coccyx. Spontaneous opening and discharge of fæces on the fifth day. No fecal discharge followed removal of drain. Pathologist's report was adenocarcinoma. Patient seen last in 1914 and presented no evidence of recurrence.

CASE VIII.—Mrs. F., Dameron Hospital, Stockton, Cal., November, 1916. High rectal carcinoma, lower border just palpable with tip of finger when patient was under anæsthetic. Abdominal incision. Resection of 3 inches of upper part of rectum and lower part of sigmoid. Denudation of rectum and invagination of closed sigmoid. Sigmoid opened with scalpel on fifth day on account of vomiting. Fecal discharge followed removal of vaginal drain, but ceased in about two weeks. Reported to be without signs of recurrence and in excellent health after ten months. Pathological report was adenocarcinoma.

## LEFT PARADUODENAL HERNIA\*

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SEVERAL varieties of paraduodenal hernia have been observed and described. Such herniæ are of considerable importance to the surgeon, because, although rarely recognized before death or before an operation for the relief of obstructive or strangulation phenomena, they may be encountered in the course of operations undertaken for the treatment of more or less commonplace abdominal disturbances. The majority of cases thus far reported have been discovered during the course of post-mortem examinations of persons having died from causes in no way associated with the hernia. A few cases are on record in which the surgeon, operating for the relief of obstruction or strangulation, found the hernia and successfully dealt with it.

The first real contribution to our understanding of this type of hernia we owe to Treitz, whose work dates back to 1857. Unfortunately, in his description of a fossa which he called "duodenojejunal," he included what is now considered a second fossa, the "paraduodenal" fossa of Landzert. Later Broesike, Gruber, Waldeyer, Landzert, and Jonnesco added greatly to our knowledge of the subject, but in so doing confused it to some extent by describing the same fossæ under different names and different fossæ under the same names, so that to review the literature would be tedious indeed were it not for the admirable monograph of Moynihan.

The terms "duodenal" and "duodenojejunal," which have been applied to this type of hernia, are somewhat misleading and might be thought to imply a displacement of the duodenum into some adventitious sac, but such is not the case; it refers to a hernia of the entire small bowel, or some part of it, into a sac derived from folds of peritoneum and fossæ normally to be found about the terminal, or fourth, portion of the duodenum. For that reason I prefer to use the term "paraduodenal" which is more accurate.

Inasmuch as a clear understanding of this type of retroperitoneal hernia involves a knowledge of the anatomy of various folds and fossæ adjacent to the fourth duodenal segment, these fossæ and their relations will be briefly described.

*Paraduodenal Folds and Fossæ.*—If the great omentum and transverse colon are reflected and pulled upward over the costal arch, and slight traction downward and to the right is made upon the jejunum, there will be seen passing from the peritoneal surface of the superior or, in some cases, of the anterosuperior, aspect of the duodenojejunal angle upward, forward and to the left side, a thin-edged, peritoneum-covered fold, the lower attachment of which is lost in the peritoneum covering this portion of the gut, the

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upper attachment blending with the root of the transverse mesocolon adjoining the splenic flexure. This is the ligament of Treitz. Its thin anterior edge is concave upward, and slightly toward the right side and the middle, narrower, portion crosses over the inferior mesenteric vein in an oblique direction upward and to the left. In the substance of this fold are involuntary muscle fibres derived from the left crus of the diaphragm. With the viscera *in situ* this fold cannot be made out, and traction upward on the colon and downward and to the right on the jejunum is necessary to bring it out.

With the colon reflected and the small bowel pulled over to the right as described, there appear in most bodies, immediately to the left of the fourth portion of the duodenum, one or more fossæ bounded by definite folds of peritoneum. Jonnesco describes in his work five fossæ. Moynihan describes nine, four of which, however, he considers of little importance.

The fossæ most frequently encountered in a consecutive examination of 100 bodies ranging in age from birth to seventy-five years are, in order of frequency:

1. Inferior paraduodenal fossa of Treitz .....	60 per cent.
2. Combined superior and inferior paraduodenal fossæ....	30 per cent.
3. Superior paraduodenal fossa .....	5 per cent.
4. Paraduodenal fossa of Landzert .....	2 per cent.
5. Duodenojejunal or mesocolic fossa .....	2 per cent.
6. Fossa of Waldeyer .....	1 per cent.

I have not been able to study these fossæ in the embryo, at which time they are said to be more frequent.

*The Superior Paraduodenal Fossa.*—Below the ligament of Treitz and on a plane posterior to it, immediately to the left of the duodenojejunal angle, there can be seen in many bodies a thin, sometimes almost transparent, fold of peritoneum extending from the peritoneal surface of the terminal portion of the duodenum toward the left, a distance of from 1 to 2 cm. This fold is, in a general way, triangular in shape, and is bounded below by a thin, semilunar margin, the concavity of which is directed downward and to the left. This fold forms the anterior boundary of a triangular fossa, usually from 1 to 2 cm. deep, the apex of which is directed upward or upward and slightly to the right and is in close relation to the pancreas. The fossa is bounded on the right by the terminal portion of the duodenum and on the left by the line of fusion between the fold and the posterior parietal peritoneum just to the right of the inferior mesenteric vein which courses in a gentle curve along the left side of the fossa (Fig. 1). This has been called by different writers the duodenal, duodenojejunal, or the superior duodenal fossa, but inasmuch as all these fossæ are *paraduodenal*, I shall call it the superior paraduodenal fossa.

*The Inferior Paraduodenal Fossa of Treitz.*—A short distance below the orifice of this superior fossa there is still more frequently another fossa bounded anteriorly by a reflection from the peritoneal investment of the fourth portion of the duodenum, posteriorly by the posterior parietal peri-

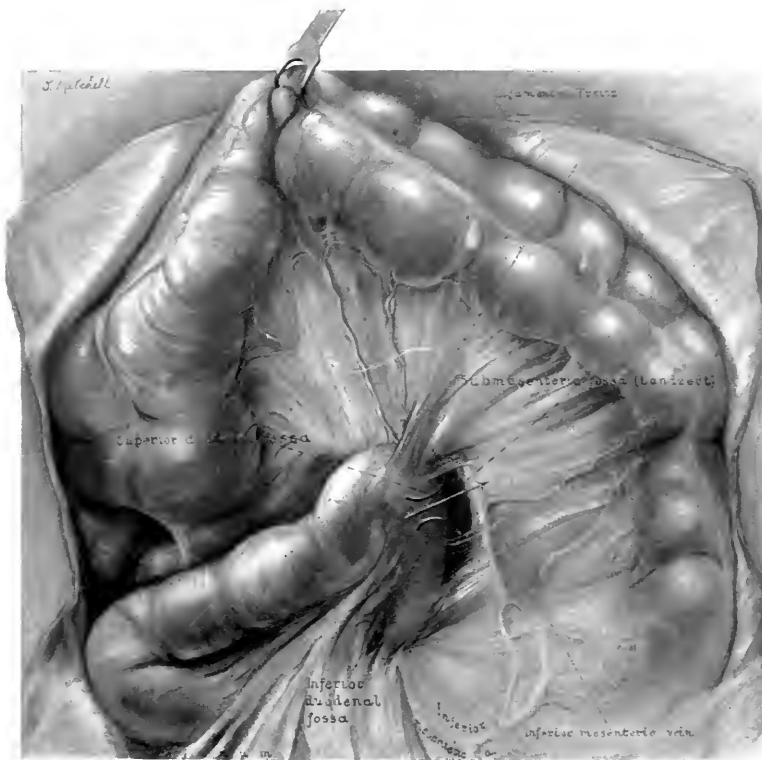


FIG. 1.—The superior and inferior paraduodenal folds and fossa, and the submesenteric fossa (Landzert).

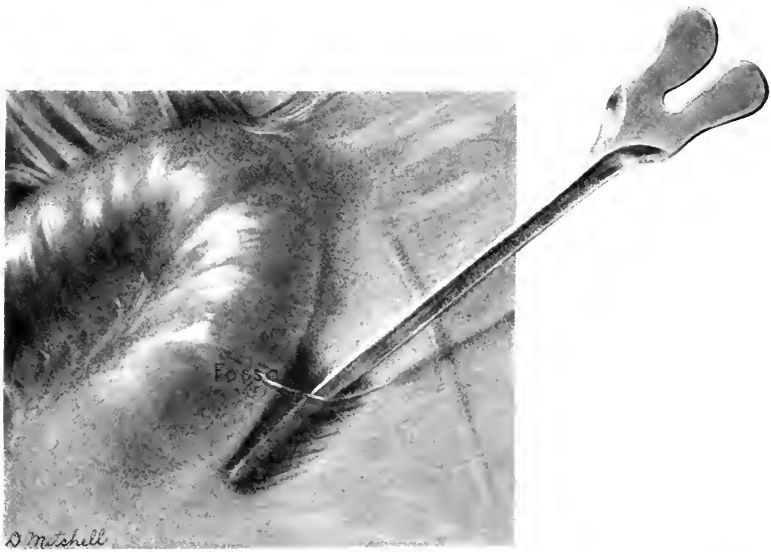


FIG. 2.—Inferior paraduodenal fossa (Treitz); director inserted into the fossa.



FIG. 3.—Superior and inferior paraduodenal fossæ with left ends of folds fused to form a common orifice for both fossæ.





FIG. 4.—Paraduodenal fossa of Landzert, showing the inferior mesenteric vein running downwards in the edge of the fold.

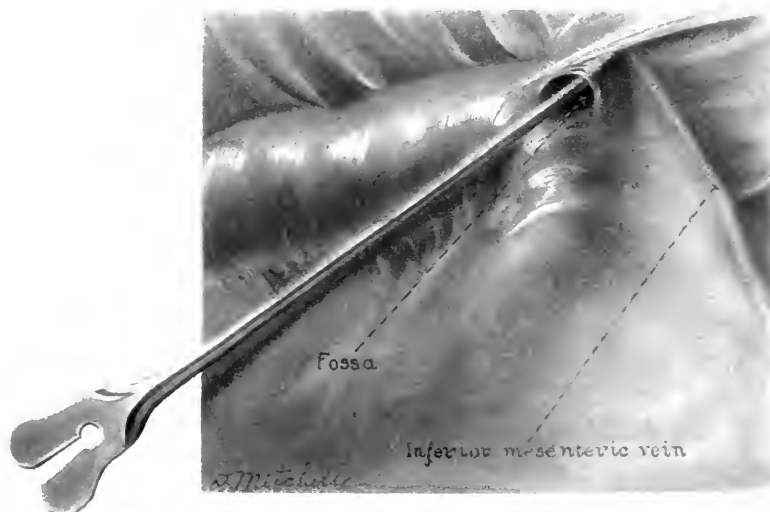


FIG. 5.—Mesocolic type of fossa with duodenojejunal angle buried in the transverse mesocolon.

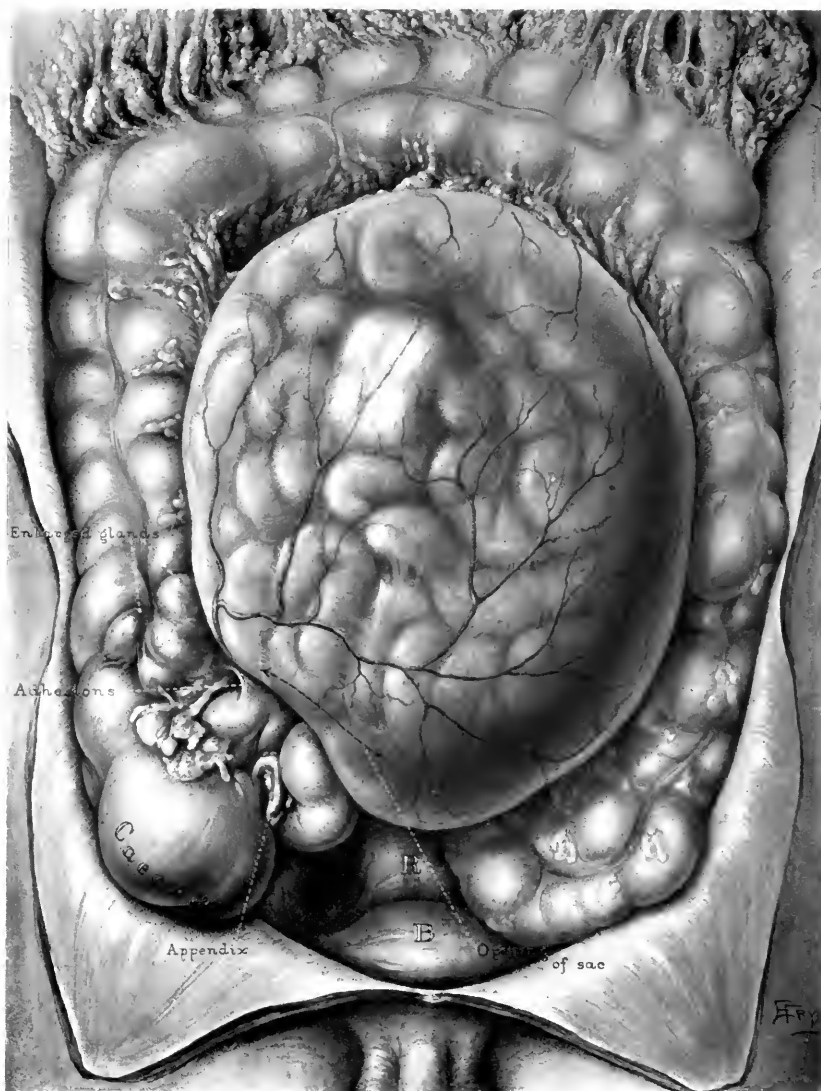


FIG. 6.—Left paraduodenal hernia as seen at autopsy. The sac contains the entire small bowel, except the terminal five inches.

toneum, on the right side by the duodenum and on the left by the line of fusion between the fold and the parietal peritoneum. The upper margin of this fold is semilunar with its concavity directed upward or upward and slightly to the left, and forms the anterior margin of the opening of a fossa of variable depth, the apex or bottom of which is directed downward and to the right immediately adjoining the fourth portion of the duodenum (Fig. 2). This is the inferior paraduodenal fossa and corresponds to the fossa described by Treitz and named by him "duodenojejunal." Moynihan describes it as the inferior duodenal fossa.

The exact position and depth of this fossa vary more or less. In three instances I was able to introduce my little finger into the fossa to a depth of 5 cm. Its usual position is along the left edge of the body of the third lumbar vertebra. In many bodies the superior and inferior fossæ coexist, and in one case the left ends of the folds forming the anterior boundary of the orifices of both fossæ had become fused into one, resulting in a common opening for both fossæ (Fig. 3).

At a variable distance below the apex of the inferior fossa the left colic artery, coursing upward and to the left, crosses the inferior mesenteric vein, the two vessels constituting the *vascular arch of Treitz*. This arch is of fundamental importance because the relations of these vessels to the neck of a hernia in this region determine its variety.

*The Paraduodenal Fossa of Landzert.*—The paraduodenal fossa of Landzert is produced by a dipping of the posterior parietal peritoneum around the right side of and behind the inferior mesenteric vein as it curves downward a short distance to the left of the fourth duodenal segment. This dipping of the peritoneum about the vein gives to the vessel a mesentery, so to speak, the vein arching to the left and then downward in the edge of the fold, the fossa being beneath or posterior to it (Fig. 4). This fossa is of great importance because it is that in which most of the paraduodenal herniæ reported have occurred, as determined by the relations of the inferior mesenteric vein and left colic artery to the neck of the sac. The extent of the fossa of Landzert varies considerably and its exact boundaries are not easy to determine because, as pointed out by Moynihan, "it exists not seldom in conjunction with other fossæ. The complications are almost as frequent as the normal." When such a complication occurs it is most frequently in the form of an associated superior paraduodenal fossa.

*The Paraduodenojejunal Fossa.*—The duodenojejunal fossa, identical with the *fossette duodéno-jéjunale ou mésocolique* of Jonnesco, is the only one of the paraduodenal fossæ which have been miscalled "duodenojejunal," to really deserve the name. In the cases in which the fossa is encountered the duodenojejunal angle is buried in the root of the transverse mesocolon, the anterior leaf of which extends farther down over the anterosuperior aspect of the duodenojejunal angle where it fuses with the peritoneal investment of this portion of the gut. In this anterior leaf of the mesocolon, just above the line of fusion, there may be seen an arched opening, in some cases so

flattened against the bowel wall as to require the introduction of a probe in order to demonstrate the fossa. The direction of the cavity is upward and to the left, the bottom of the fossa being in close relation to the pancreas and inferior mesenteric vein (Fig. 5). Jonnesco describes a similar fossa with a double opening which is merely a modification. This duodenal fossa is to be found in from 5 to 10 per cent. of bodies examined.

*The Mesocolic Fossa.*—The fossa described under this name by Moynihan is quite uncommon, but it is of some importance as the possible origin of a hernia. It is located at some distance from the ascending fourth portion of the duodenum, to the left of the inferior mesenteric vein, and extends to the left between the leaves of the mesocolon in the region of the splenic flexure. A branch of the left colic artery runs upward in the fold, forming the anterior boundary of the fossa.

*The Paraduodenal Fossa of Waldeyer.*—Waldeyer, in 1874, described a fossa in the mesojejunum, beneath the superior mesenteric artery and immediately below the duodenum, which he called "mesentericoparietal" and which Moynihan considers of more frequent occurrence than some of the other fossæ described in his work. In 100 bodies examined I have seen it but once, and although the relations of this fossa were those mentioned, I am inclined to consider it as a variation from the more common inferior fossa of Treitz. I have seen a number of low fossæ of Treitz, the bottom or apex of which was in intimate relation to the beginning of the fourth portion of the duodenum, and it does not require a considerable stretching of the imagination to associate the fossa of Waldeyer with a low inferior paraduodenal fossa of Treitz. Moynihan's description is as follows: "The fossa has its orifice to the left, its blind extremity to the right and downward. In front it is bounded by the superior mesenteric artery and behind by the lumbar vertebræ. The peritoneum of the left leaf of the mesentery lines the fossa, that of the right covers the blind end, and is then continued directly into the posterior parietal peritoneum." It is in this fossa that a right paraduodenal hernia occurs, and since we are dealing only with the left type of hernia it will not be referred to again.

Three other fossæ have been described, but they are so rare and of so little importance that they need not be considered.

*Origin of Paraduodenal Folds and Fossæ.*—Several explanations of the origin of these folds and fossæ have been advanced. The first interpretation was that of Treitz, who considered them to be due to the movement of the intestine associated with its embryonic development. During the early stage of its development the intestinal tract consists of a fairly simple and straight tube attached to the midline of the body by a fold of peritoneum. As it grows the stomach becomes differentiated by a dilatation of the tube, and the tube below this gastric dilatation increases in length. Associated with this development is a movement of the stomach from its original longitudinal position with its surfaces looking to right and left, to a transverse position, the original right surface of the stomach becoming posterior and its former

## LEFT PARADUODENAL HERNIA

left surface the anterior. As this movement, with which the duodenum is associated, takes place, there is a gradual fusion of the peritoneum about these structures. Treitz's view was that the increasing length and consequent dragging of the intestine exerting traction on the fixed duodenum and mesocolic root were responsible for these folds, and that the fossæ were the result of these "traction" folds. This view is now quite untenable.

Waldeyer's theory was based on the relation of the inferior mesenteric vein to the neck of the sac. He thought that, in the course of development of the posterior parietal peritoneum, the vein raised a fold forming a fossa, and for that reason he considered the fold as *vascular* in origin. This view cannot be accepted because there are several folds and fossæ which have no such vascular relationships.

The logical explanation, which covers the embryologic and anatomic requirements, is that of Moynihan, who looks on them as "fusion folds between the original left, afterwards anterior, surface of the ascending portion of the duodenum and the right, or anterior surface of the descending mesocolon folds, which date their origin from the time when these two peritoneal surfaces are in close apposition." This interpretation makes it possible to understand the frequent occurrence of atypical fossæ.

*Factors Involved in the Production of Hernia.*—Treitz has formulated three postulates as indispensable for the occurrence of a left duodenal hernia:

1. The presence of a fossa.
2. The presence of the neck of the sac of the inferior mesenteric vein.
3. Sufficient mobility of the small bowel to allow it to pass into the sac derived from this fossa.

However, it would seem that, beside these factors, there would be required an increased intra-abdominal pressure sufficient to initiate the hernia, because the natural drag of the intestine is away from these fossæ, the opening of which is seldom large. It is conceivable that in some cases the hernia may be congenital, having been produced as a result of increased intra-abdominal tension either before or during parturition.

The second postulate may or may not be fulfilled, depending on whether or not the hernia is one into the paraduodenal fossa of Landzert, because this is the only fossa with which the vein is in such close relation.

REPORT OF A CASE OF LEFT PARADUODENAL HERNIA.—Case 193232 is that of a man fifty-six years of age, who came to the Mayo Clinic May 4, 1917, seeking relief for shortness of breath and abdominal distention. Physical examination revealed an enlargement of the right lobe of the thyroid, multiple firm, nodular masses in the upper abdomen, an enlarged, palpable spleen, and a large quantity of fluid in the left pleural cavity causing a considerable displacement of the heart to the right. On the same day a supraclavicular gland was removed for microscopic examination and proved to be lymphosarcomatous. I merely mention these facts without dwelling on them because they have no bearing on the hernia, except to show that the patient had never had any symptoms

that might lead one to suspect the presence of an abdominal condition in no way responsible for his death, which occurred on May 8.

At the necropsy performed fifteen hours after death the following pertinent lesions were named as the lethal factors in the anatomic diagnosis: Marked general lymphosarcomatosis; chronic nephritis; cardiac hypertrophy and bilateral hæmohydrothorax.

The following is a transcript of the description of the hernia made at the time:

"On opening the abdominal cavity the small intestine appears as in the early stage of a plastic peritonitis. The coils seem slightly adherent, and hyperæmic, but it is strikingly noteworthy that the intestinal mass has a sharply ovoid shape, smooth and uniformly rounded, occupying the centre of the abdominal cavity with the colon forming a frame about it as shown in Fig. 6. On attempting to separate some of the coils, however, it is at once apparent that the bowel is covered by a thin, transparent membrane in which vessels can be seen coursing from above downward and from below upward. The mass is about the size of a human head looked at from above; it measures over all 20 cm. in its longitudinal diameter and 17 cm. in the transverse. There is an interval of 5 cm. between the lower pole of the mass and the symphysis pubis. Recognizing a hernial sac and seeking its orifice, I find it above and behind the lower pole and to the right of the middle line, in the form of a long, oblique opening slightly semilunar, with its concavity pointing downward and to the right. The anterior margin of the neck of the sac is thick and cord-like and passes upward and to the right to the space between the sac and the ascending colon where it becomes lost in the retroperitoneal tissues, among masses of enlarged glands. At the left and inferior end of the opening the cord-like anterior margin of the neck curves upward and to the left to blend with the descending mesocolon. Four fingers can be readily introduced into this orifice up to the metacarpophalangeal joints. Traction on the lower pole upward and to the left brings the orifice into view and it is seen that the entire small bowel, with the exception of the terminal 5 inches of ileum, is inside the hernial sac. There are no adhesions between the bowel and the sac.

"The normal anatomic relations are so distorted by the enormous enlargement of all the retroperitoneal lymph-glands that, in order to determine the variety of this hernia, it is necessary to work out the relations of the inferior mesenteric vein and left colic artery to the sac. The inferior mesenteric vein passes beneath the posterior parietal peritoneum across the back of the hernial sac to the space between it and the ascending colon on the right side. Then coursing downward and inward to the right margin of the hernial orifice it passes from right to left in the thickened anterior margin, forming the anterior boundary of the neck to the left side.

"The left colic artery runs toward the left side, where, after coursing downward in the space between the sac and the descending colon, it enters the left side of the anterior margin of the hernial orifice and passes through it upward and to the right side. From both vessels as

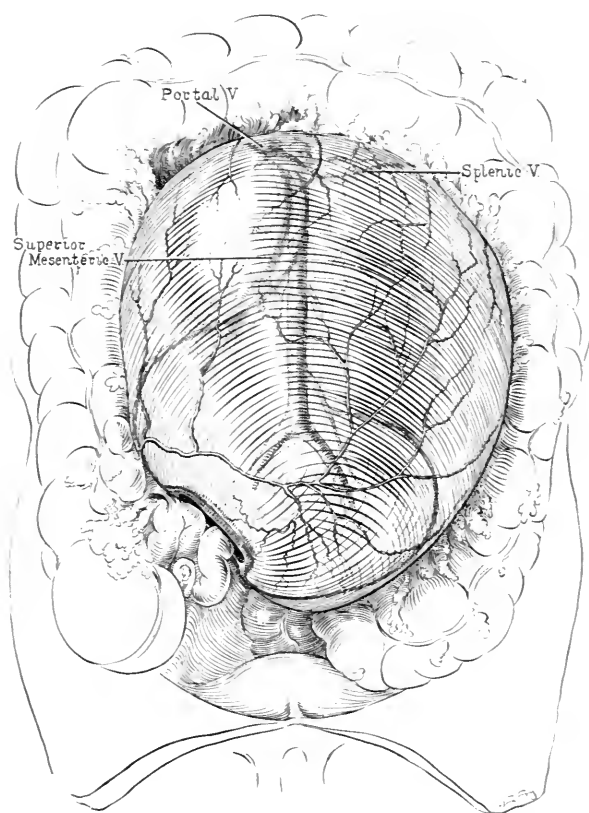


FIG. 7.—Diagram showing the relations of the inferior mesenteric vein and left colic artery to the hernial sac





## LEFT PARADUODENAL HERNIA

they pass through the thickened band forming the anterior margin of the neck of the sac, branches pass upward between the two fused layers of the sac itself. Similar branches pass downward from the middle and left colic vessels, running in the space between the sac and the transverse and descending colon."

The accompanying diagram (Fig. 7) gives a better idea of these relations. This, then, is a hernia into the paraduodenal fossa of Landzert and is to be classified as a left paraduodenal hernia.

In his monograph published in 1906 Moynihan gives a list of 65 cases reported up to that time. Since then A. Rendle Short has collected 17 more cases, one of which, however, had already been reported by Moynihan, making, up to 1914, a total of 81. Of the 16 cases collected and listed by Short, 7 patients were operated on and recovered. One of these cases, that of Heller, was a complete hernia, very similar to my own.

Since the beginning of 1914 I have been able to gather the four following cases:

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## THE DISTRIBUTION OF FAT IN THE APPENDIX AND ITS RELATION TO INFLAMMATION\*

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THE accumulation of visible fat in various regions of the body has long been a matter of study; and much clinical and experimental data are now at hand to show the relation of fat to normal and pathologic processes. With the exception of the blood-vessels, the solid parenchymatous organs have been of chief interest for their variations in content, distribution and nature of fat. It is only in more recent times, with the renewal of interest in the study of lipoids, caused by the application of improved methods of analysis, that some of the hollow organs of the abdominal cavity have become the object of investigation.

It is a matter of general knowledge, particularly since the researches of Rosenfeld,<sup>1</sup> that the visibility of fat in tissues is not necessarily a true index of the entire fat content of the organ, for many of the lipoids found in tissues are held in an invisible combination with other substances, becoming an object of visible demonstration only when chemically liberated from the substances with which they are associated. On the one hand, a kidney showing a marked fatty condition on gross or microscopic examination, when chemically analyzed may show no increase in fat over what is normal. On the other hand, a kidney exhibiting on inspection or by staining methods very little or no fat, may be found to contain an unusually high percentage of fat when chemically examined. For practical purposes, however, any extensive accumulation of visible fat in an organ is regarded as satisfactory evidence of pathologic increase in its content of fat.

Many investigations have been undertaken to explain the process by which an abnormal deposit of fat occurs. In a general way it may be said that the body stores fat in various regions under normal circumstances, and these places are often referred to as "fat depots." The sites for storage of fat vary somewhat at different periods of life; and even the chemical composition of the fat may show variations, depending upon the locality in which the fat is found. Fat depots are in regions such as the panniculus, the fatty capsule of organs, the mesentery and in the tissues of the mammary gland. These regions, as Kawamura<sup>2</sup> has pointed out, are chiefly neutral fat, formed by glycerine esters. Considerable amount of fat exists in the body, however, formed by cholesterine esters, characterized by the physical properties of being doubly refractive or anisotropic, showing a cross of light when examined by polarized light. These fatty globules exist normally in the adrenals, thymus and the lutein cells of the ovary, and are

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\* Read before the Connecticut State Medical Society, New Haven, Conn., May 24, 1917.

## FAT IN THE APPENDIX AND INFLAMMATION

found as abnormal fats in other parts of the body. There is still another large group of fatty substances, called myelin substances, which become visible only under strictly abnormal conditions. When, for instance, as the result of a profound disturbance, tissues become necrobiotic or autolytic, myelin droplets are formed. The term fat phanerosis has been applied to the condition where invisible lipoids become visible under abnormal circumstances.

Organs affected with a pathologic accumulation of fat often show special anatomical areas where the deposit of fat is greatest in amount. In the blood-vessels and in the heart it is characteristically sub-endothelial, although the musculature of both the blood-vessels and the heart may be strikingly affected. In the liver the storage of fat is within the liver cells; while in the pancreas fat forms between the lobules and among the acini. In the appendix, as will be explained, the accumulation of fat appears to be mostly in the submucosa.

The problem of fat accumulation is associated with cellular metabolism, in which oxidation is probably the chief fault. As Wells<sup>3</sup> has pointed out, constituents of fat (as glycerine and fatty acids) are brought to cells through the medium of tissue fluids, and are there converted by the enzyme lipase into the forms of fat useful for the growth and function of the particular cell. The intracellular fat is resolved again into its constituents by other enzymes when occasion demands their use. Anything interfering with the synthesis or with the breaking down of the fats may cause abnormal accumulation of fat either within the cells of an organ, or in neighboring tissues, for lipase is found in all body fluids and may act to form fats at any point where the proper conditions for this process exist. Any severe injury to cells, such as is produced by certain poisons, may cause an abnormal formation of fat in the cells affected. Injury to tissues through inflammation appears also to be associated with fat accumulation. As examples of this it may be said that chronic inflammations of the kidney cause fatty degeneration of renal epithelium. In pneumonic processes of long standing, areas of fatty tissues may occasionally be found. In the periphery of chronic abscesses and edges of growing tumors lipoids can, at times, be demonstrated. Aschoff<sup>4</sup> has pointed out that fatty substances, particularly cholesterol, may be found in the mucous membrane of the gall-bladder when this is the site of inflammation.

As far as can be ascertained by a review of the literature, the relation of fat formation to inflammation of the appendix has not been defined. The occurrence of fat in the appendix was first noted by several of the earlier anatomists, chiefly incidental to the study of the so-called involution of the appendix. The materials for this study were from autopsies. Wolfer<sup>5</sup> was probably the first to note that fatty tissue existed in the obliterating appendix. In a small number of appendices of adults examined by him there was found a loss of mucous membrane of the appendix and the submucosa formed a network of fatty tissue.

Zuckerkandle<sup>6</sup> studied with much care the obliteration of the appendix, contributing a great deal to our knowledge of the histology of this condition. It is not necessary to go into details of his work at the present time, except to point out that he thought the presence of fat played an important part in causing obliteration of the lumen of the appendix. In thirty-seven appendices examined, which had shown an atresia of the lumen, seventeen contained fat; two showed areas of fat and areas without fat; eighteen were without fat, among these nine with a contracting atrophy of the appendix. Zuckerkandle believed that the early evidence of obliteration of the appendix occurred as a great thickening of the submucosa, which was supplied not only with an increased number of blood-vessels but also with fat to such a degree that, on cross section of the appendix, it might look like a lobule of fat. These masses of fat were arranged radially and were traversed by connective tissue. In what he believed represented a somewhat later stage, the connective tissue appeared more dense, nearly or entirely free from fat. The final stage of obliteration Zuckerkandle recognized anatomically as a thin cord-like appendix, with no fat or only an occasional globule.

Suduski<sup>7</sup> also studied autopsy material and found that in young individuals no fat was present in the appendix; while in older subjects, even in the absence of all traces of obliteration, considerable amount of fat might occur. Suduski found appendices showing early obliteration without fat at the site of the lesion. He did not agree therefore with Zuckerkandle's views that an accumulation of fat was associated with an early phase of obliteration. All these investigators regarded the obliteration of the appendix as a process of involution and not of inflammatory origin.

It is generally conceded, at the present time, that what is known as partial or complete obliteration of the appendix is in a large part the outcome of chronic inflammation, which gives rise frequently during life to clinical symptoms, yet often remains clinically unrecognized. Inflammatory changes in the appendix, which are clinically obscure, may begin in early infancy. In 200 appendices in infants under one year, which I had occasion to examine at autopsy, 17 showed histologic evidence of inflammation.<sup>8</sup> MacCarthy,<sup>9</sup> in a study of a vast amount of material, found that partial obliteration might be present as early as the fifth year, and complete obliteration was seen as early as the tenth year. He estimates that the average time necessary for complete obliteration of the lumen of the appendix is approximately four years and believes that inflammatory processes must determine these rapid changes. As is well known, with increasing years, evidence of obliteration is more and more frequent so that, at the end of the sixtieth year, over fifty per cent. of all appendices at autopsy show evidence of this condition.

#### METHODS AND RESULTS OF STUDY

The present work is based on the gross and microscopic study of 217 appendices removed at operation, gathered principally from the surgical material of the Waterbury and St. Mary's Hospitals. These tissues were

FIG. 1.

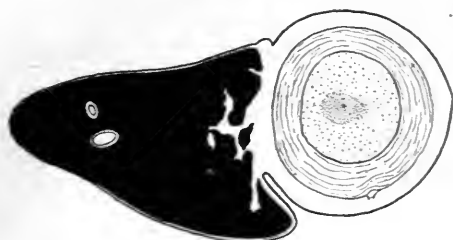


FIG. 2.

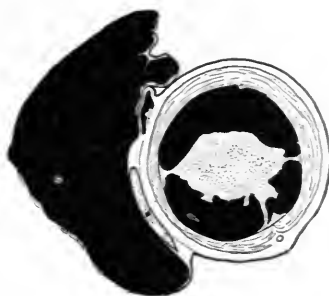
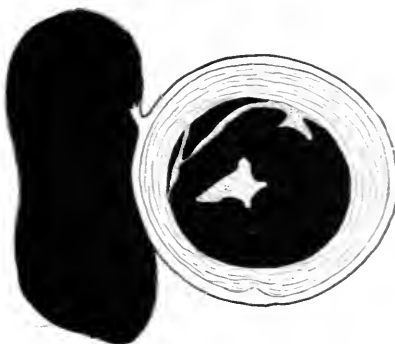


FIG. 3.



FIG. 4.



FIGS. 1-4 are diagrammatical drawings made from cross-sections of gross appendices, chronically inflamed, stained with Scharlach R. for fat. In the figures, black areas represent tissues taking the fat stain. Fig. 1, chronic appendicitis without increase in fat. (Meso-appendix alone takes the stain.) Figs. 2, 3, and 4, chronic appendicitis with marked increase in fat which has accumulated in the thickened submucosa.



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fixed in formalin and sectioned transversely with a razor into small segments, 2 to 5 mm. thick. After formalin fixation for 48 hours, the appendices were washed for a half hour and placed in an alcoholic solution of Sudan III or Scharlach R for from two to three days. All fats were stained red by this time and the tissues were then removed and permanently placed in 10 per cent. formalin. Blocks, for microscopic study, were taken from the appendices as a rule before staining the gross tissues in Sudan. Blocks were cut on the freezing microtome and stained with Sudan and mounted in glycerine for study.

A preliminary gross study was made of the entire gastro-intestinal tract, treated in this way, of a normal adult, age 25 years, six feet tall, who died four days after an accident.

It was found that the walls of the œsophagus in this individual contained no visible fat. The wall of the stomach was also fat free, except in a few of the larger folds of the stomach where fat was present in very moderate amounts situated in the submucosa. There were small amounts of fat in the submucosa of the pylorus. The duodenum, jejunum and ileum did not stain for fat. The ileocæcal valve, however, showed considerable amounts of fat. The cæcum, the colon, the sigmoid and the rectum showed definite yet moderate amounts of fat in the submucosa. The ileocæcal valve was most conspicuous for its content of fat. In four other specimens, removed at autopsy, fat in the ileocæcal valve seemed abundantly present. The appendix of this normal individual was patent throughout and showed fat here and there in the submucosa, especially at its base and in the fold corresponding to the valve of Gerlach. The extreme tip was fat-free.

It would seem from this single study of what approaches normal adult conditions as closely as possible that any large fold or valve of the gastro-intestinal tract may contain fat, and that fat forms part of the structure of the submucosa of the large intestine and the appendix. In the foetus and in the infant this fat was not visible in either the cæcum or the appendix. In ten appendices belonging to late fetal life or early infancy, no visible fat was demonstrated in either the cæcum or the appendix. This is in harmony with the view of Suduski, who believes that fat makes its appearance after birth and is present, to some extent, in all appendices of adults.

There were 132 appendices examined, removed for disease of the appendix, which could be classified as chronic appendicitis. It was apparent at once that the deposit of fat was an important feature of the obliterative process. In most of these appendices fat was present, and this varied in amount over a wide range. In some appendices fat was absent or nearly absent; in others fat was extreme and formed the most conspicuous feature of the lesion. It would appear from this, that chronic appendicitis actually divides itself into two groups: the first exhibiting no increase in fat, the second showing an unusual accumulation of visible fat. It was more common to find that the region at the base of the appendix was affected and contained more fat than did the tip, even though it is common knowledge

that obliterative changes often make their earliest appearance in the distal end of the appendix. At sites of stricture fat was found more often than not; yet it was almost the rule that the fat, at the points of stricture, was no greater in amount than elsewhere in the appendix. Twelve cases out of 154 cases of chronic appendicitis, showed a marked condition of fat accumulation. These fatty appendices all exhibited a tendency to obliteration of the lumen. Histologically the fat was in large masses or small globules in all parts of the thickened submucosa, which encroached upon or filled the lumen. Fat globules were found between the muscle bundles or actually in the muscle substance, slight amounts occasionally in the serosa. A striking feature was the massing of fat about the blood-vessels, and this fact suggests the possibility that circulatory disturbances play a rôle in the origin of fat. The mucous membrane showed little fat, except that the epithelial cells may contain fatty granules as they do under normal circumstances when absorbing fat from the content of the intestine. When epithelium contained fat it was usually in small groups of cells scattered here and there, particularly those deep in the folds of the mucous membrane.

Clinically this condition of fatty appendix occurred in the male sex six times, in the female thirteen times. In several of these patients there was a tendency to obesity. It was seen as early as the sixteenth year, while the oldest patient exhibiting the condition in this series was 42 years of age. The condition of fat in the meso-appendix was no index of the extent of fatty involvement in the appendix itself. In one patient the condition was associated with chronic cholecystitis with stones, in another with chronic salpingitis. The wall of the gall-bladder showed a slight amount of fat, the tube showed none. The clinical histories of patients with fatty appendices appeared to differ in no way from that of the usual chronic case of appendicitis. From the histological study of these appendices one gets the impression that there is a great massing of fat about the blood-vessels and lymphatics, particularly the former. This would point to the possibility that circulatory disturbances, in addition to inflammation, play a part in the abnormal accumulation of fat in the tissues of the appendix, particularly as bends, kinks, twists and adhesions are so common in this type of appendicitis. Impairment of circulation under experimental conditions has been found to contribute to abnormal formation of fat in the tissue involved. According to Fischler<sup>10</sup> this has been found to be the case in the margins or edges of infarctions where circulation is impaired yet where tissues are still viable. Dietrich<sup>11</sup> noted the appearance of fat in tissues implanted into the peritoneal cavity. The characteristic "tigering" of the heart seen at autopsies when the heart is the site of fatty degeneration is usually attributed to impairment in circulation.

In acute suppurative or gangrenous appendicitis, of which 85 specimens were examined, visible fat plays a less conspicuous part in the lesion. It is not infrequently the case, especially in gangrenous appendicitis, that small areas of the wall of the appendix take on a dull orange color when stained



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with Sudan. Such orange zones are found in any part of the wall, and microscopically the tissues comprising these zones show a granular light yellow stain. These areas probably represent fat phanerosis in necrobiotic or autolytic regions. Where an acute condition is grafted on a chronic process, fat is present and shows a distribution such as that already described above for chronic appendicitis.

### SUMMARY

The larger folds of the stomach, the pylorus, the ileocaecal valve, the large intestine and the appendix contain normally moderate amounts of fat in the submucosa. Fat in the appendix makes its appearance after birth.

Chronic inflammation of the appendix may be associated with or without an increase of visible fat. In about 14 per cent. of appendices examined which were chronically inflamed fat was very much increased and affected occasionally the muscular coat as well as the submucosa.

Abnormal accumulation of fat in the appendix is induced by inflammation, aided probably by impairment of circulation in the wall of the appendix.

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## SPONTANEOUS PAN-HYSTERECTOMY AFTER ABDOMINAL CONTUSION

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THE following case seems worthy of record:

April 21, 1917: A. L., white female, aged twenty-nine years, living in poor surroundings. She has been married ten years, has had five children, all living. No miscarriages nor stillbirths. Patient gives a history of always having been strong and healthy. She has had no serious illness in her life.

About the middle of March, at which time the patient considered herself two months pregnant, she was knocked down by a partly filled molasses barrel falling against her. Beyond bruising she apparently suffered no injury.

April 13 she "found herself beginning to flood." This continued the next day and was accompanied by severe abdominal pain. Bleeding lessened somewhat the next day but the abdomen continued very tender. A midwife was called in that evening.

The next day, April 16, the patient was unable to void urine "because something seemed to be pressing against the opening."

The midwife gently pressed down over the bladder (resembling Credé manoeuvre?) and a mass was expelled through the vagina "looking like a baby's head" but hanging by a few shreds of tissue. The midwife called in another woman, as the mass did not "come away." Moderate bleeding continued. The shreds were cut and the mass removed. At that time the abdomen was so tender that the patient could not bear to be moved or touched. Bleeding stopped April 17. A doctor had been sent for, as they despaired of the woman's life. In the two days necessarily intervening before my arrival the patient had begun to get better.

Physical examination showed an adult, fully developed, moderately nourished female lying comfortably in bed with cheeks slightly flushed. The temperature was 100.5°, pulse 96 and the respirations 24. Heart and lungs were normal. Pulse was good quality. The abdomen was moderately distended with some rigidity low down. There was tenderness above the pubes and a tender mass palpable low down in the right iliac fossa. The rest of the abdomen was but slightly tender. The patient could be moved about the bed without complaining of any pain and was put in lithotomy position.

On examination there was a gangrenous mass protruding through the vulva which proved to be omentum. The uterus was absent from position and its place occupied by a mass most prominent in the right vault. No loop of intestine was incarcerated in the vagina. There was a moderate purulent discharge.

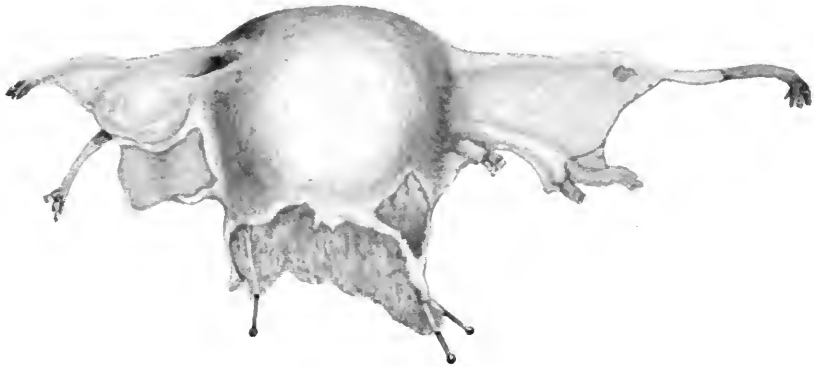


FIG. 1.—Uterus with appendages viewed anteriorly.



FIG. 2. —Posterior view. Pins have been placed in openings of uterine vessels.



## SPONTANEOUS PAN-HYSTERECTOMY

The sloughing omentum was tied off as far up in the vagina as possible. A daily douche of hot perchloride 1: 4000 was instituted. The patient was put in the Fowler position and on liquid diet. She had morphia gr.  $\frac{1}{4}$  hypo.

April 21: Temperature was 100°, pulse 96 and good quality. Patient had a comfortable night and was in good condition, asking to be given solid food. She was voiding without pain, but the bowels had not moved since her illness began.

May 26: "The following word was received, "Patient got up on April 30, for first time, and began to get about a week ago. She feels fine. There is no pain. She is able to do her work now."

The specimen shown readily explains itself. It had been split anteriorly for examination. The line of separation seems to follow almost the lines of the usual pan-hysterectomy except that it includes more of the broad and the whole of the round ligaments. There are also both tubes, the left ovary, the complete uterus and part of the vagina. The specimen is represented in Figs. 1 and 2 from drawings by Dr. Wilfred T. Grenfell, to whom I am gratefully indebted for his interest and kindness in making them. He has purposely made them somewhat diagrammatic, but correct as to size and relations. The specimen, having been in formalin, was decolorized, and Dr. Grenfell has supplied the color by description. The location of the uterine vessels is shown by some of the pins which were used in mounting the specimen.

# INTESTINAL OBSTRUCTION: AN EXPERIMENTAL STUDY

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WITH THE COLLABORATION OF

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THE experiments described in this paper were carried out for the purpose of obtaining material for a study of the chemical nature of the toxins formed as a result of intestinal obstruction. The experiments, however, illustrate some important facts bearing on the problems of intestinal obstruction independent of the chemical nature of the toxic substances formed.

Murphy and Vincent<sup>1</sup> have shown from experiments on cats that the interference with the blood supply to loops of obstructed bowel is a very important factor in bringing about early severe symptoms and death in the experimental animals. They showed that following the obstruction and strangulation of a loop of bowel the animal showed signs of very grave intoxication in 4-6 hours. Hartwell and Hoguet<sup>2</sup> have shown that the severity and rapidity of development of symptoms is in direct ratio to the extent of damage to the mucosa of the obstructed bowel. Whipple, Stone and Bernheim<sup>3</sup> found that isolated obstructed loops of jejunum caused death in 72-76 hours. They state that it is possible for the animal to die as a result of intestinal obstruction without there being demonstrable abnormality of the mucosa of the obstructed loop. They believe that in such instances there is absorption of the toxic substance directly from the mucosa and not from the lumen of the obstructed bowel. Murphy and Brooks<sup>4</sup> called attention to the fact that in a study of the intoxication following intestinal obstruction it was essential to differentiate clearly two factors, viz., the production of the toxic substance, and the absorption of the toxic substance. It was stated that the latter was the more vital factor. It was demonstrated that the toxin was of bacterial origin and was not absorbed by the normal intestinal mucosa. These observers believed that the most essential factor in determining the absorption of the toxin from the obstructed loop of bowel was a disturbance in the nutrition of the mucosa as a result of strangulation or rapid distention of the bowel.

Dragstedt, Moorehead and Burcky<sup>5</sup> have shown that sterile isolated obstructed loops of bowel cause no intoxication even if such loops perforate and discharge the contents into the peritoneal cavity. If, however, the isolated obstructed loops contained bacteria and if there was tissue necrosis, the animals showed signs of intoxication. The authors emphasize the importance of the tissue necrosis but do not state clearly whether they believe the

## INTESTINAL OBSTRUCTION

necrosis of tissue is a factor in the production of the toxin or in the absorption of the toxin.

The following described experiments were carried out on dogs: Only three experiments will be described. These experiments have been repeated many times in connection with other experimental studies with constant results. The operations were always done under complete surgical anæsthesia, and the usual surgical aseptic precautions were carefully observed. Every effort was made to prevent pain and suffering in the experimental animals. When the animals did not die as a result of the experiment they were sacrificed by the administration of chloroform.

EXPERIMENT No. 1.—Dog. Weight 10.8 K. April 4, 1917. 10 A.M.

Ether anæsthesia. Laparotomy. Tape tied about highest portion of jejunum. Another tape was tied about the ileum. Approximately 100 cm. of bowel occluded between tapes. All of the veins in the mesentery of the occluded bowel were ligated. Abdomen closed.

Seven hours: Animal is desperately sick. Vomiting. No stools.

Twenty-one hours: Animal found dead. Occluded loop very much distended. The loop content consisted of 330 c.c. of thick bloody fluid of foul odor; the bowel wall was swollen and hemorrhagic. The mucous membrane was completely destroyed.

Thirty c.c. of the loop content injected intravenously into a healthy dog weighing 6 K. caused death in 8 hours. Autopsy of the injected animal showed the mucosa of the duodenum and jejunum swollen and red.

Other animals which received intravenous injections of smaller amounts of the loop content showed symptoms but did not die.

EXPERIMENT No. 2.—Dog. Weight 18 K. April 16, 1917.

Ether anæsthesia. Laparotomy. The jejunum was sectioned as high as possible. Both ends of the sectioned bowel were turned in. The bowel was sectioned again 40 cm. distal to the previous section. Both ends turned in. Lateral anastomosis between the proximal and distal stumps. Abdomen closed.

This operation gave an isolated occluded loop of jejunum 40 cm. long. Special care was taken in turning in the ends of the isolated segment. Only a very small amount of bowel wall was inverted.

One day: The animal is up.

Two days: Dog is up. Eats. Does not look sick. No vomiting.

Six days: Animal eats. Seems rather drowsy. No vomiting.

Seven days: Animal looks drowsy. Weight 13.6 K. Anæsthetized. Abdomen opened. Isolated loop found completely closed. Markedly distended. Bowel wall showed no evidence of necrosis. The distended isolated loop was excised. The abdomen was closed. The animal ultimately completely recovered.

The isolated obstructed loop contained 350 c.c. of a thick, gray colored material. The mucosa appeared rather more opaque than normal. It was, however, quite smooth and velvety. There was a small ulcerating spot at either end where the bowel had been turned in. Otherwise the bowel wall seemed quite normal.

Three c.c. of the loop content was diluted with 7 c.c. of sterile water and given intravenously to a dog weighing 5 K. The injection was followed by frequent vomiting, passage of bloody stools, collapse and death in 3 hours. Autopsy of the animal injected showed a marked hemorrhagic mucosa of the duodenum and jejunum and the entire lumen of the bowel was filled with bloody mucous material.

EXPERIMENT No. 3.—Dog. Weight, 10.8 K. April 21, 1917.

Ether anæsthesia. Laparotomy. A loop of jejunum 80 cm. in length was isolated and the ends very carefully turned in so as to invert the least possible amount of

bowel wall. The continuity of the intestinal tract was re-established by lateral anastomosis between the proximal and distal stumps of bowel. Abdomen closed.

Two days: Animal is up. Seems quite well.

Fifteen days: The animal is losing weight. Eats well. No vomiting.

Twenty-one days: For the past week the animal has seemed somewhat drowsy. Eats well.

Weight 7.2 K. No vomiting. Does not seem particularly sick. Sacrificed.

Autopsy showed the isolated loop completely closed. It was markedly distended. The intestinal anastomosis was healed. The peritoneal cavity appeared quite normal. The bowel wall shows nothing abnormal on the peritoneal surface (Fig. 1). The content consisted of 400 c.c. of a thick gray material of very foul odor. The mucosa of the occluded loop was opaque white in color. It was smooth and velvety. There were a few small irregular hemorrhagic areas, suggesting beginning necrosis in the bowel wall. There was complete healing of the inverted ends. Microscopic sections of several areas in bowel wall showed some infiltration of the tissue with lymphocytes. The tips of the villi were oedematous. The epithelial cells were absent from the tips of the villi. The epithelium of the deeper glands seemed normal.

Two c.c. of the loop content was injected intravenously into a dog weighing 7.2 K. After the injection the animal vomited frequently, passed bloody stools, showed extreme collapse, and died in 7 hours. Autopsy showed a very marked hemorrhagic mucosa of the duodenum and jejunum. The lumen of the entire length of the bowel was filled with a blood-stained mucous material.

These experiments illustrate some facts which should be thoroughly appreciated by the clinical surgeon and the laboratory worker who is concerned with the problems of intestinal obstruction.

In Experiment No. 1, in which there was extensive damage to the bowel wall from venous stasis, the animal died in less than 21 hours. The content of the obstructed loop consisted of 330 c.c. of material of which 30 c.c. represented a lethal dose for a 6 K. dog when it was given intravenously. That is, the entire loop contained at death only about 10 lethal doses for a 5-6 K. dog. In Experiment No. 2, in which there was a simple obstruction of an isolated loop of jejunum and in which special care was taken not to expose areas of damaged mucosa to the possibility of absorption of the loop content, the animal lived for 7 days without showing signs of severe intoxication, and then made a complete recovery after the excision of the isolated occluded loop which contained at least 115 times the amount of toxic material necessary to kill a 5 K. dog in 3 hours, when given intravenously. During the last day of this experiment the animal was beginning to show signs of absorption of the toxic loop content, manifest by the continuous drowsiness. This was the result of the distention of the occluded loop to point at which there was beginning nutritional change in the mucous membrane and a beginning impairment of its normal selective absorptive power.

Murphy and Brooks<sup>4</sup> called attention to the fact that simple obstruction of segments of upper jejunum resulted in earlier symptoms and death than similar obstruction of loops of ileum because the "higher" loops became more rapidly distended from the greater amount of secretion of fluids into the lumen of the bowel, and consequently more rapid nutritional change in the mucous membrane. In Experiment No. 3, a relatively long loop of bowel



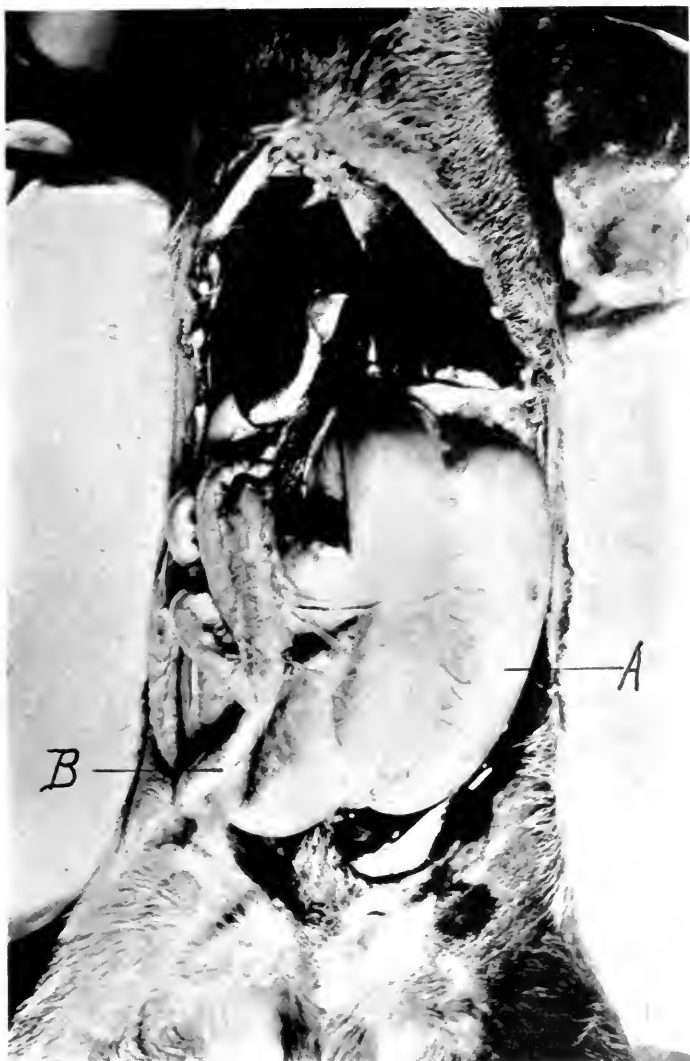


FIG. 1.—Experiment No. 3. Photograph showing the distended, isolated, obstructed loop of bowel of twenty-one days' duration. A, distended isolated loop; B, intestine which was not obstructed.



## INTESTINAL OBSTRUCTION

was isolated and occluded. In such a loop there is probably a sort of a balance between the excess of secretion of fluid into the lumen of the proximal end and the excess of absorption of fluids from the lumen of the distal end. In this experiment the dog was sacrificed at the end of 21 days and the animal was at this time only beginning to show signs of absorption of the toxic loop content. The occluded loop contained 400 c.c. of material, 2 c.c. of which injected intravenously into a healthy dog weighing 7.2 K. caused death in 7 hours.

These experiments show the importance of distinguishing clearly between the two factors, production of toxin, and absorption of toxin. In Experiment No. 1, in which there was the maximum of opportunity for absorption of the toxic loop content, death resulted before the loop content had attained a high degree of toxicity. In Experiment No. 3, in which there was little damage to the mucosa from the operative procedure and in which the occluded loop distended slowly and there was little nutritional change in the mucosa, the animal showed relatively little evidence of intoxication at the end of 21 days, although there was produced in the occluded loop two hundred lethal doses of the toxic substance if given into the circulation. In Experiment No. 2, in which the loop was relatively shorter and higher and in which distention of the bowel and absorption of the toxic substance developed more rapidly, there was an earlier appearance of symptoms. Whipple, Stone, and Bernheim,<sup>3</sup> and Murphy and Brooks<sup>4</sup> have shown in many experiments that short high occluded loops of jejunum, in which special care has not been taken in turning in the ends of the bowel, distend rapidly and result in death in 72-96 hours.

That the failure to develop symptoms in these instances of simple obstruction of loops for long periods is not a result of the animals developing immunity has been proven by Dragstedt, Moorehead, and Burcky,<sup>5</sup> who have shown that symptoms and death rapidly follow the ligation of the veins of such loops. We have also found that an animal having an isolated occluded loop of several days' duration has no demonstrable immunity to the toxic loop content if given intravenously.

In Experiment Nos. 2 and 3, there was no necrosis of tissue and yet there was in each case production of a large quantity of highly toxic loop content. It can not be denied that necrosis of tissue may increase the rapidity of formation of the toxin, but actual visible tissue necrosis is not necessary to the production of a very toxic loop content. It seems more probable that necrosis of the bowel is more a factor in bringing about the absorption of toxin than in its production.

It is interesting to note that in some experimental work which is as yet not published it has been found that an isolated occluded loop of bowel of several days' duration will absorb glucose readily at same time that it contains a large quantity of very toxic material which is not absorbed.

These experiments also illustrate another fact which has been previously mentioned in the reports of the experimental work of Hartwell and Hoguet,<sup>2</sup>

Whipple, Stone, and Bernheim,<sup>3</sup> Murphy and Brooks,<sup>4</sup> and Dragstedt, Moorehead and Burcky,<sup>5</sup> but which has never been appreciated by a large number of clinical surgeons. This fact is as follows: *The toxic substance produced in the lumen of obstructed bowel is not absorbed by the normal intestinal mucosa.* The belief that the acute symptoms of intoxication which may follow the relief of an intestinal obstruction are due to the absorption of the toxins of the obstructed bowel after the toxic fluid has passed into the normal bowel distal to the obstruction, is disproved by these and many other experiments. That a patient may grow rapidly worse immediately after the release of an intestinal obstruction cannot be denied, but the reason for this is not that the normal bowel distal to the obstruction absorbs the toxic substance after it is passed through the point of previous obstruction. There are other explanations which are not contradictory to experimental work. It may be in such instances that the operative measures damage the mucosa at some point, *e.g.*, an intestinal anastomosis, and thus permit a more rapid absorption of the toxins already formed. In case of strangulation or volvulus it may be that the operative relief of the obstruction to the blood- or lymph-vessels permits a more rapid absorption of the toxic loop content from the already damaged mucosa. Or it may be the patient has already absorbed a lethal or near lethal dose of the toxic substance before the operative procedure is undertaken. In which case, the operation is merely an incident in hastening the onset of the fatal or near fatal condition from its general effects rather than from any effect on the subsequent absorption of the toxins. The last is probably most often true.

The method described in Experiment No. 3 is of particular value to the laboratory worker who is interested in the study of the chemical nature of the toxins of intestinal obstruction. It permits of the collection from a single animal of a large quantity of highly toxic loop content. From such a loop a large quantity of the toxic proteose-like substance which has been described by Whipple<sup>6</sup> may be easily obtained. Certain differences in the chemical nature of the toxic substances of obstructed loops of different periods of duration, which seem to indicate the manner of formation of these toxins, will be reported in a later paper.

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# THE ETIOLOGICAL RELATIONSHIP OF BENIGN ULCER TO CARCINOMA OF THE STOMACH\*

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## INTRODUCTION

DEFECTS of the gastric mucosa are frequently found in conjunction with gastric carcinoma, but the etiological relationship of benign ulcers of the stomach to gastric carcinoma is as yet an unsettled question. In the following investigation we have tried to ascertain whether a microscopical study of a series of benign and malignant ulcerations of the stomach would throw any added light upon this subject.

Certain difficulties were encountered which we believe are inherent in such a morphological study, and which have also been noted by other observers. There is at present a complete lack of experimental means available for this investigation. None of the animals, domestic or wild, are susceptible to spontaneous chronic gastric ulcers, and for this reason, in all probability, no satisfactory method has been found to consistently produce chronic gastric ulcers in animals so that the course of these ulcers can be studied.

At present the only criteria we have for determining if a gastric ulcer develops into a carcinoma are based on microscopical evidence.

## DEFINITION OF TERMS

A number of terms will be continuously employed throughout this paper and for the purpose of clarity are herewith defined:

*Ulcer.*—Solutions of surface continuity extending to a varying depth and showing no evidence of carcinomatous structure; employed in the commonly accepted usage as indicating a defect which shows no tendency to heal.

*Carcinoma.*—Tumor formations of a carcinomatous nature with the surface continuity unbroken. These include cauliflower-like tumors with sessile or pedunculated bases and diffuse infiltrations of the stomach wall.

*Ulcerated Carcinoma.*—Tumor formations in which defects have occurred but in which the gross appearance of tumor formation is present and evident.

*Ulcer-like Carcinomatous Lesions.*—Defects having the gross appearances of benign ulcerations but in which the total structure is demonstrated microscopically to be composed of carcinomatous tissue.

*Mixed Lesions.*—Defects resembling in all gross characteristics the appearance of ulcers (as above defined) but in which at one or more points of the periphery there are areas composed of definite carcinomatous tissue.

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## MATERIAL STUDIED

*Gastric Ulcers.*—Thirty-eight typical chronic gastric ulcers were examined. These presented the typical gross and microscopical appearances which characterize a chronic gastric ulcer. The variations found in these lesions were all within the usual limits and none showed any definite indication of malignancy.

*Microscopical Studies.*—Microscopical examination reveals a great similarity in the pathological processes in the majority of the specimens. All the ulcers show certain prominent characteristics. The edge of the ulcer is sharp, as though cut off, even when it is overhanging. The mucosa at the edge shows only a superficial degeneration and a moderate grade of chronic inflammation consisting of congestion, oedema and diffuse infiltration with mononuclear leucocytes, plasma cells and a few polymorphonuclear leucocytes. The glandular structures at the edge of the ulcer show slight degenerative changes of their cells. Some of the glandular acini or crypts have the appearance of being cut off and do not reach the surface of the mucosa but terminate at the edge of the ulcer. Whenever found, the cells of the acini are contained within their basement membrane but show a tendency in some specimens to a moderate hyperplasia.

In the main the hyperplasia consisted of glands which were more tortuous than normal, sometimes with cystic-like dilatation. In places these cells of the acini were piled one upon the other. It is hard to differentiate, however, the appearance of piled-up cells from the appearance presented by glandular acini where the section has been made tangential to the periphery of the gland. There was always a tendency in the piled-up cells for the nuclei to remain at one end of the cell and not to approach the centre. These nuclei were also practically normal in appearance and did not have the dark staining, dense qualities which nuclei of carcinomatous cells have. The lining, *i.e.*, the surface of the ulcer, consists of a narrow layer from one-eighth to one-third the diameter of a low-power field of the microscope in thickness and is made up of degenerating and necrotic fibrous tissue. The layer of degenerating tissue fuses with or is transformed into dense fibrous tissue, although the line of demarcation is clearly seen. The fibrous tissue extends for a considerable distance, in places as much as 1 cm., into the submucosa and muscularis. It has the typical characteristics of scar tissue and seems to form a wall beneath the ulcer. Some of the ulcers have completely penetrated the stomach wall, but the edges are always covered by the above structures and the bare muscularis is never exposed. The connective-tissue septa, which lie between the muscle bundles and are accompanied by blood-vessels, are increased in size by fibrous tissue and dense infiltration with mononuclear leucocytes. Similar areas of fibrosis and infiltration are found beneath and in the serosa.

Occasionally, but only rarely, prolongations of the degenerating surface layer, several millimetres in size, are found in the dense fibrous tissue layer, but these are always completely limited by the latter.

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In a few of the specimens the diagnosis of ulcer was arrived at with considerable difficulty because of atypical hyperplastic forms at the edge. The reasons of this will be given at length under the heading of "discussion."

*Gastrojejunal Ulcers.*—Five specimens were studied and showed the typical gross and microscopical appearances of chronic gastric ulcer with the additional factor, probably due to location, of a greater degree of fibrosis about them and a greater redness of the serosa in the neighborhood, indicating acute and subacute inflammatory changes. One of these specimens is of especial interest, inasmuch as the ulcer recurred at a second gastrojejunostomy which was performed at the same site after the first gastrojejunal ulcer had been resected. Four of these occurred after a posterior no-loop gastrojejunostomy, three by the suture method and one by the Murphy button. One occurred after an anterior suture gastrojejunostomy. In none of these was Pagenstecher thread found projecting from the ulcer, although in three of the operations Pagenstecher was used in the outside serosa suture of the anastomosis. This is important, as apparently linen thread suture material had nothing to do with the etiology of these ulcers. This is also demonstrated by the ulcer which occurred after the Murphy button gastrojejunostomy. The same degree of hyperplasia was found microscopically as was present in the chronic gastric ulcers, but no indications of malignancy were present.

*Healed Gastric Ulcers.*—Two specimens were studied. In both the healed ulcers were situated over the lesser curvature of the pyloric antrum. In one the glands had undergone a marked cystic dilatation; in the other compressed and atrophic glandular acini were found in the midst of the scar tissue at the level of the muscularis. In neither were any signs of carcinoma present.

*Ulcer-like Carcinomatous Lesions.*—Seven specimens were studied. These constituted a very interesting group. Grossly these lesions could not be differentiated from chronic gastric ulcers. In several, however, malignancy was suspected, but in the remainder we were very much surprised to discover, on microscopical examination, that the defect showed an infiltrating carcinoma extending around the entire edge and into the base of the ulcer and the stomach wall around it.

There is one additional specimen which belongs to this group which was discovered at autopsy. This patient had a general carcinomatosis with a most extensive intra-abdominal and retroperitoneal involvement. The primary tumor proved to be a carcinoma of the lesser curvature of the stomach, which grossly had the appearance of a gastric ulcer and appeared insignificant compared to the metastases which had emanated from it. The remainder of the stomach showed malignant involvement of the lymph-nodes on both curvatures, but the wall was soft and normal in appearance. Microscopically, however, a network of malignant cells were found everywhere in the lymphatics throughout the serosa.

*Carcinoma.*—The study of the structure of many specimens of frank

carcinoma of the stomach added nothing to the solution of the problem under discussion and descriptions of these lesions will not be included here.

*Chronic Gastric Ulcer with Carcinomatous Involvement of Regional Lymphnodes* (One Specimen Studied).—This lesion presented a typical appearance of a chronic gastric ulcer. Microscopical sections were made of practically the entire lesion. Carcinoma was not found in any of these sections. The ulcer was situated on the lesser curvature, 4 cm. from the cardiac orifice of the stomach. At operation palpation of the cardiac orifice and lower portion of the oesophagus failed to reveal a neoplasm.

A detailed description of this specimen follows:

SPECIMEN "U" (Fig. 17).—*Macroscopical*.—The specimen ( $5 \times 6$  cm.) consists of a portion of the stomach measuring six centimetres along the lesser curvature.

Two centimetres from the cardiac end of the specimen and situated at the lesser curvature is a deep, oval, punched-out ulcer,  $1.5 \times 1.2$  cm. in size and 1 cm. in depth. The edge is sharp cut, but the mucosa at the other end is slightly overhanging. The lining is pinkish gray in color, apparently consisting of granulations. The ulcer seems to extend through all the coats of the stomach and for a slight distance into the gastrohepatic omentum. The remainder of the gastric mucosa is slightly reddened, but otherwise normal. In the gastrohepatic omentum which has been resected are a number of lymphnodes about one centimetre in diameter which are slightly firmer than normal. On section the lymphnodes are succulent, translucent and pinkish gray in color. One lymphnode was removed separately, about  $1.5 \times 2$  cm. in size, and is slightly firmer than the others. Its centre is broken down, forming a small irregular cavity.

On section through its centre, the ulcer is found to have penetrated all the coats of the stomach into the gastrohepatic omentum. Radiating from the base into the tissue about it are firm, fibrous bands, giving the cut surface a fan-like appearance.

*Microscopical*.—The sections show a typical indurated ulcer. The edges are sharp and the mucosa is not overhanging. About one centimetre away from the edge of the ulcer there are found a few deep reaching glands of the mucosa extending slightly beyond the remainder of the mucosa in the midst of the muscularis mucosa. These glands, however, are perfectly normal in appearance. There is no sign of any attempt at malignant transformation at any place. The ulcer is lined by the usual type of degenerating material, and here and there with the Gram Weigert stain, in and upon the degenerating lining, a moderate number of cocci, large and small bacilli and yeasts are found. None are found in the depths.

Lymphnode from lesser curvature: Structure is almost entirely replaced by malignant tumor which has the appearance of a squamous cell carcinoma, including pearl formation.

Another lymphnode shows chronic inflammation and fibrosis. No bacteria are seen with the Gram Weigert stain.

*Carcinoma Occurring in an Apparent Chronic Gastric Ulcer*.—A detailed description of one specimen in the group follows:

SPECIMEN "W" (Figs. 9-14) (See Photograph for Diagram of Blocks Studied).—*Macroscopical*.—The specimen consists of the pyloric antrum. In the middle of the lesser curvature of the specimen is an indurated area, about three to four centimetres in size. On opening the stomach, beneath this indurated area, a saddle shaped ulcer is found, four by one and one-half centimetres in size, reaching down from the lesser curvature on to both anterior and posterior walls of the



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stomach. The edge of the ulcer is raised and its mucosa is reddened. The ulcer is deep and sharp cut, and varies in depth from four millimetres to one centimetre. The edge of the ulcer nearest the cardia is definitely overhanging. Just to the pyloric side of the ulcer, about two millimetres from its edge, is a round, superficial ulceration, one centimetre in width. The ulcer proper reaches through the muscularis and extends into the serosa and to a certain extent into the gastro-hepatic omentum. The edge of the ulcer is rather firm in consistency, but does not have the appearance of new growth. The remainder of the mucosa is somewhat reddened. No other ulcerations are found. The lymphnodes over the lesser curvature are somewhat enlarged.

On section the ulcer is found to have penetrated through all the coats of the stomach and the base of the ulcer is surrounded by a layer of dense, fibrous tissue, about one-half centimetre in width. Immediately beneath the small superficial ulcer area described above and near the edge of the ulcer, a round area which is somewhat translucent, having the appearance of either a lymph-node or an isolated piece of muscularis, is found.

*Microscopical.*—Section 1: Section is that of an ulcer-like lesion. The defect has the typical outline of an ulcer. The mucosa at its very edge is extremely atypical, composed of solid columns of cells apparently extending into the interstitial tissue, having the appearance of early malignancy. Immediately next to this at the edge of the atypical mucosa is a fairly well demarcated, rounded area of medullary colloid carcinoma which has definitely infiltrated the submucosa. The mucosa farther on beyond the colloid area and farther away from the edge of the ulcer is fairly normal except for slight inflammatory changes and hyperplasia of some glands.

Section 2: Shows portion of the base of an ulcer which has the appearance of a chronic ulcer. The tissue beneath this is fibrous and adipose, showing inflammatory changes.

Section 3: Shows a lesion with the typical outline of chronic gastric ulcer with an overhanging edge. The glands at the exact edge show the usual type of inflammatory and hyperplastic processes seen in gastric ulcers. A very short distance beyond this, however, over an area about the width of the low power field of the microscope, the superficial glands are extremely atypical in appearance. They are definitely invading the interstitial tissue, and are made up of irregularly arranged cells, the nuclei of which are dark staining, are situated approximately at the centre of the cell and show a moderate number of mitotic figures. This area is definitely carcinomatous and in places one portion of the gland appears to be normal and the other portion carcinomatous. The small area of mucosa between this and the edge of the defect shows the usual regenerative processes seen in gastric ulcer but is not carcinomatous. The remainder of the mucosa shows slight inflammatory changes only.

Section 4: Consists of a portion of stomach wall covered by practically normal mucosa showing slight inflammatory changes.

Section 5: Edge of ulcer. The base of the defect has the typical appearance of that of a chronic ulcer. The mucosa at the edge and for quite a distance away shows a typical adenocarcinoma of the type usually found in the stomach. This carcinomatous area is quite sharply demarcated from the normal mucosa which makes up the remainder of the section.

Section 6: The section is that of a portion of the base of the defect which has the appearance of a chronic ulcer.

Section 7: The edge of the defect has the appearance of that of a chronic ulcer. The mucosa at the very edge shows an atypical appearance of its glands with an extreme degree of hyperplasia. The cells are confined within the basement membrane and therefore no carcinoma is present in this section.

Section 8: Consists of an ulcer-like lesion. The base of this lesion has the appearance of that of a chronic gastric ulcer. At the very edge of this lesion is a small nodule of typical colloid carcinoma. Immediately beyond this for quite a distance the mucosa is replaced by a typical adenocarcinoma. This latter stops rather abruptly, but seems to merge with the normal mucosa which makes up the rest of the section.

Gram Weigert Stain: A careful search was made of all of the above described sections stained with the Gram Weigert stain and in only one of them a small collection of cocci was found upon the surface. No organisms were found in the depth.

Specimen "W" showed in several sections no carcinoma. We believe this specimen satisfies all the requirements laid down by Stromeyer to prove that a carcinoma can develop in a gastric ulcer.

#### DISCUSSION

In the light of the preceding gross and microscopical descriptions of the lesions studied it is seen that the material consists of:

1. Specimens in which there is no doubt as to whether the lesion is benign or malignant.

2. A specimen in which a part of the lesion is definitely benign and other parts are definitely malignant.

3. A few specimens in which the diagnosis is arrived at with difficulty.

The diagnosis in these latter cases (Group 3) is always a matter of personal opinion based on accumulated experience. The matter becomes all the more difficult when one considers the work of Bullock, who has shown that under the influence of chronic irritation it is possible to produce lesions in epithelial structures which resemble malignant tissue microscopically. Yet a removal of the source of irritation is promptly followed by a regression and disappearance of the suspicious structures. This experimental work applies in the human cases in those border line lesions in which one must distinguish between hyperplastic forms in the edge of the defect and an early malignant transformation. In a certain number of the cases the microscopical appearance of the lymphnodes draining the infected area can give deciding information, for the presence of metastatic carcinoma in these furnishes a ready and accurate method of differentiation. This is well illustrated by specimen 26, a description of which follows:

*Macroscopical.*—The specimen consists of the entire antrum. Immediately beneath the lesser curvature in the middle of the specimen there is an irregular deep ulcer about one and one-half centimetres in width. The edge is somewhat undermined and along the edge are numerous irregular red elevations. The base is gray in color. Extending from the ulcer in an irregular fashion towards the greater curvature are two more superficial ulcerations which are serpiginous in character. One of these is about  $1 \times 2$  cm. and the other is  $1 \times 3$  cm. in size.

*Microscopical.*—The sections are from several portions of irregular ulcerations. In general the picture presented is that of chronic ulcer, in addition to which, however, a very peculiar proliferative process in the mucosa is present, which in several places is definitely malignant even though it is a very early stage of malignancy. At the edge of the ulcer-like process the glands of the mucosa show an extreme hyperplasia.

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Many of these glands, although they retain practically their normal shape, are made up of irregularly arranged cells, the protoplasm of which stains a deeper red than normal and the nuclei of which are irregular in position and shape, many of them being larger than normal and all of them staining a deeper blue than normal. In the depth of the ulcerated portion of the mucosa at the edge of the ulcer, the glands can be traced into irregular projecting columns of the epithelial cells which generally are situated in the midst of connective-tissue stroma. The base of the defect shows over its middle portion no mucosa, but degenerated fibrous tissue upon a fibrous tissue foundation. The hyperplastic glands near the edge, however, extend for a considerable distance upon the sides of the base of the ulcer and some of these glands present a picture of an early carcinoma, whereas others are practically normal in appearance. The base of the ulcer, where these glands are present, is covered by an almost continuous line of epithelium which is almost normal in appearance, but here and there these cells resemble the malignant cells described above.

A lymphnode from the lesser curvature is situated immediately beneath the ulcer-like lesion and shows in the lymph sinuses at the periphery of one end groups of carcinoma cells, with no adenomatous arrangement.

As a general rule we believe it may be stated that, when the microscopical picture is of such a nature as to give rise to doubt, in all probability the atypical forms are hyperplastic and not malignant. There is no adequate laboratory method available at present for proving this point absolutely. These lesions have therefore been classified by us as ulcers.

Latterly the etiological relationship between carcinoma and ulcer has received much attention and the belief has gained ground that carcinomatous transformation of a benign ulcer takes place very frequently. Stromeyer had described morphological criteria for judging the etiological relationship between ulcer and carcinoma. These criteria are in substance as follows:

When the defect is surrounded completely, both in the base and on the periphery by malignant tissue and the latter extends deepest at a point corresponding to the centre of the base of the defect, the lesion is a primary carcinoma upon which a defect has been superimplanted. When an ulcer has a base which is entirely free of tumor tissue and the periphery shows only at one point atypical carcinomatous forms, an opinion may be entertained that carcinoma has become implanted on a preëxisting ulcer.

In any event we believe that a judgment must be made with the following limitations:

1. The observation is made at one stage of the development and the picture obtained gives no clue as to (a) the age of the lesion; (b) the preceding condition, especially at the inception; and (c) in benign lesions, the final outcome if the lesions had been undisturbed.

2. Normal growth, hyperplasia, and malignancy make use of the same underlying laws which govern the growth of tissue, and of necessity instances will often occur in which the differentiation between hyperplasia and malignancy becomes a matter of great difficulty.

3. The amount of necrosis which so frequently occurs in malignant tumors. The importance of this element becomes apparent on referring to the accompanying diagrams:

FIG. 1: The amount of necrosis is at a minimum. The defect is then entirely surrounded both on the periphery and in the base by carcinomatous tissue.

A more extended necrosis may result in (a) Fig. 2—defects in which the base is free and the entire periphery is carcinomatous; (b) Fig. 3—defects in which part of the base and periphery only are carcinomatous; (c) parts of the periphery are carcinomatous, either at one point (Fig. 4) or at more than one point (Fig. 5) equally or unequally.

Fig. 6: The degree of necrosis is near the maximum and the bulk of the tumor is digested away, leaving a base which is entirely free of carcinoma and a periphery in which small fragments of definite tumor tissue appear or in which it is difficult to say whether one is dealing with hyperplasia or malignancy.

It is in just such cases as last described that the chief difficulty arises in formulating an opinion as to the primary benignity or malignancy of the given defect. For one may argue equally well that (a) the tumor was primary and the necrosis was extensive and secondary, or (b) the ulcer was primary and a malignant transformation has occurred at one point. In either case the microscopical picture is identical.

It is only with a lesion of this kind that it is ever possible to say with any degree of certainty that carcinoma has become implanted upon an ulcer. In the others,—cases of ulcerated carcinoma—the picture at the moment of examination is so overwhelmingly that of tumor that one must consider the superimplanted defect as secondary and unimportant. The actual percentage of mixed lesions in the total is very small, in our series 2 per cent.

In an argument of this nature evidence from clinical sources is unreliable and must be disregarded. For it is well known that even under the best of conditions the diagnosis of ulcer is always difficult and frequently is only decided at exploratory operation. "Ulcer" symptoms are frequently proven on operation to be of a neurogenous or functional nature or to be dependent upon lesions in foreign viscera, either near by, as in the gall-bladder, or at a distance, as in the appendix. To say then, that the previous symptoms of the patient, from whom an ulcerated carcinoma has been removed, point to the preëxistence of an ulcer, upon which the tumor has been implanted is, therefore, fallacious. The futility of this argument is further apparent when it is considered that a preëxisting ulcer might have healed entirely and that the tumor which was found was an entirely new lesion.

Much food for thought was given by the arrival in the laboratory of specimen "U," described above. (Chronic gastric ulcer with carcinomatous regional lymphnodes.)

The explanation of this anomalous condition could be made upon only one basis which our observations, previously outlined, supported, namely that a squamous cell tumor had grown in the stomach wall and had metastasized in the lymphnodes. That in the tumor itself the maximum amount of necrosis had occurred and the entire carcinoma had been digested away, leaving what was apparently a benign ulcer.

This brought up the question of the nature of those large indurated

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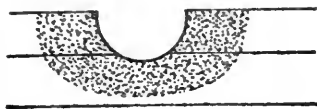
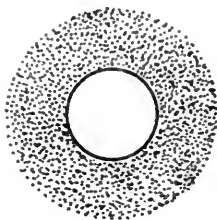


FIG. 1.

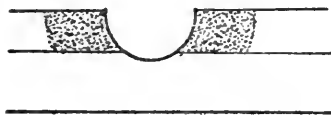
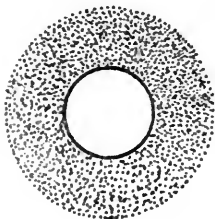


FIG. 2.

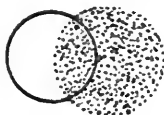


FIG. 3.

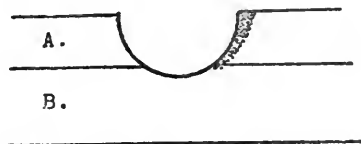


FIG. 4.

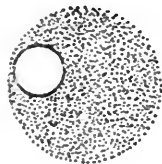


FIG. 5.

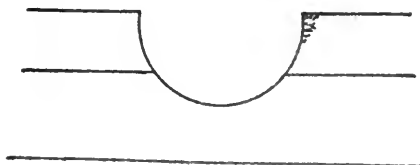


FIG. 6.

FIGS. 1 to 6.—Diagrammatic representation of the possible relationship of a defect to a carcinomatous lesion to the stomach wall. A full view and a cross-section is given in each figure. The dotted areas represent carcinoma. The segments of the circles represent the relative position of the defect. A, mucosa; B, remainder of stomach wall.

and crateriform, perforating or penetrating ulcers of the lesser curvature and posterior wall of the stomach. For many reasons these can be considered to form a class by themselves. And in the light of what our studies have shown, especially specimen "U," it is not unreasonable to question whether these were not originally carcinomatous tumors in which the amount of necrosis has been near to or at the maximum. There are several points which support this view:

1. Ulcers situated elsewhere, such as those near the pylorus or in the duodenum, are practically never known to undergo carcinomatous change.
2. Carcinomatous changes are found only in ulcers of the lesser curvature and posterior wall. The mixed lesion studied by us was an indurated defect situated on the lesser curvature.
3. The gross appearances of these lesions give no indication of the true microscopical structure.
4. Among our specimens we found examples which illustrate the progressive changes from the lesion which is truly an ulcerated carcinoma to that in which the only evidence of the carcinomatous origin is the presence of a metastatic focus in a regional lymphnode. Intervening between these, all stages can be shown which had resulted from varying amounts of necrosis.

#### RÉSUMÉ OF MATERIAL STUDIED

Forty-eight ulcerated lesions of the stomach comprise the material studied. This includes 39 chronic ulcers, 7 ulcer-like carcinomatous lesions, 1 ulcer with regional carcinomatous lymphnodes, and 1 mixed lesion (resembling an ulcer but with carcinoma at many places on its periphery). This summary does not include 5 gastrojejunal ulcers and 2 healed ulcers which were also investigated.

#### CLINICAL SIGNIFICANCE OF THE RESULTS

In going through our records one finding is significant, namely, that 14.6 per cent. of the specimens studied were ulcer-like lesions which on microscopical examination proved to be ulcerated carcinomata. If the specimen of ulcer with regional carcinomatous lymphnodes and the mixed lesions are included, then 18.7 per cent. of the ulcer-like lesions were associated with carcinoma. In all of these it was not possible to make the diagnosis of malignancy from the gross appearance of the specimens as they were observed at the operation. In view of this fact the surgeon must consider that the large indurated ulcers occurring on the posterior wall and lesser curvature of the stomach are potentially carcinomata until the microscope discloses their true nature. Any method of treatment which does not aim at a complete removal of the lesion, with the appropriate regional lymphnodes, must be considered faulty, inasmuch as the risk is always present that a carcinomatous lesion has been allowed to remain. In the same way any method of treatment, such as the *cautery method of Balfour*, which destroys



FIG. 7.—Edge and base of benign gastric ulcer (x 60).

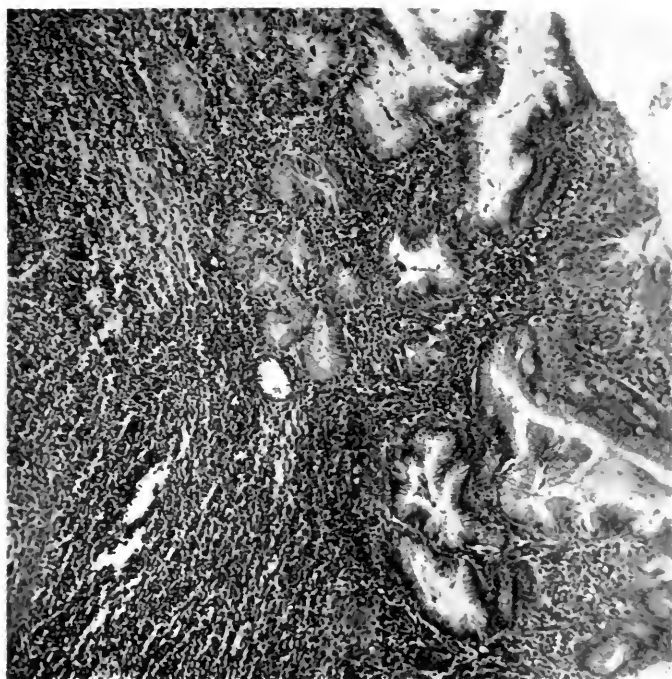


FIG. 8.—Same ulcer (x 80).

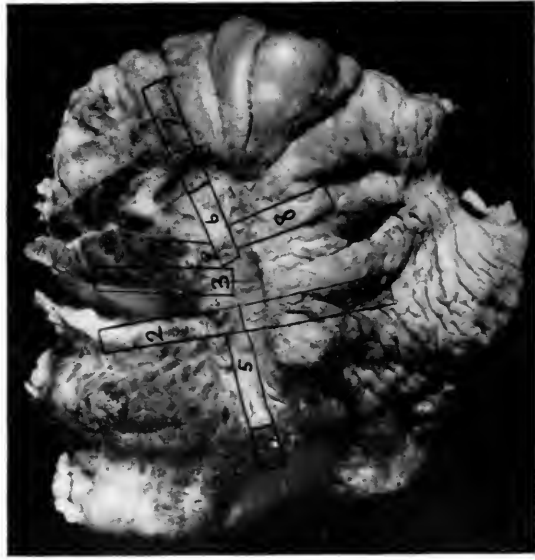


FIG. 9.—Specimen "W."



FIG. 10.—Specimen "W." Edge of lesion showing no carcinoma (x 60).



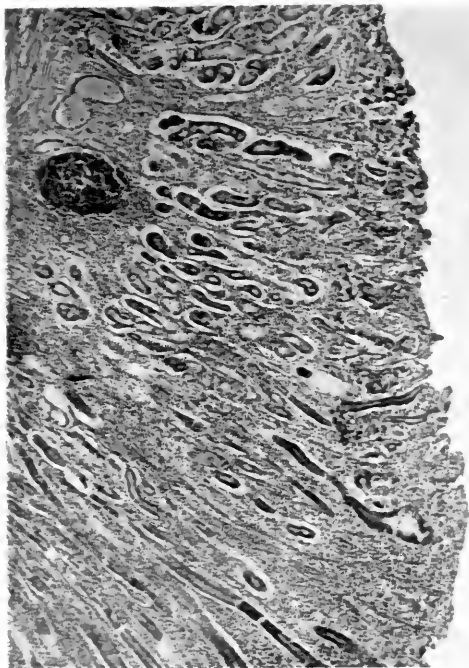


FIG. 11.—Specimen "W." Near the edge of the lesion showing superficial carcinoma (x 60).

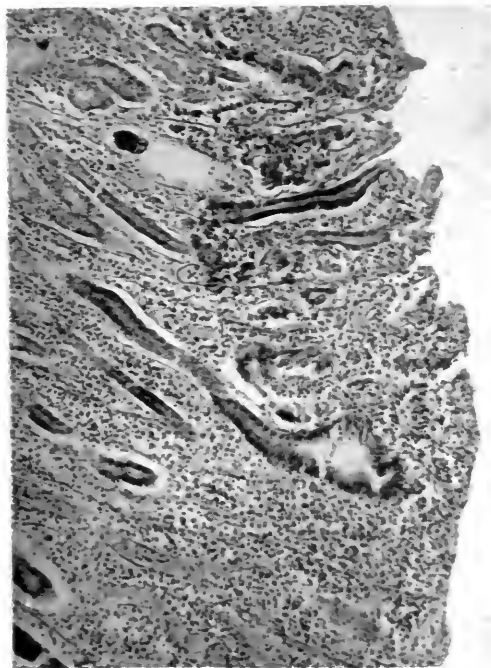


FIG. 12.—Specimen "W." Same area (x 60).

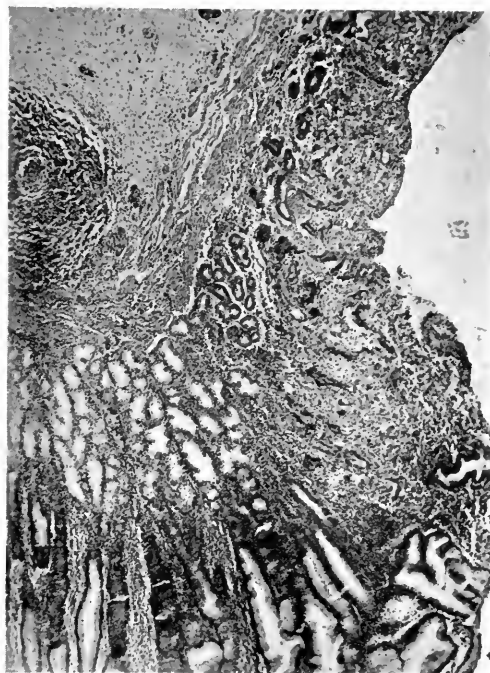


FIG. 13.—Specimen "W." Edge of lesion showing carcinoma of edge and base (x 60).



FIG. 14.—Specimen "W." Edge of lesion showing early stage of adenocarcinoma and also colloid carcinoma (x 80).

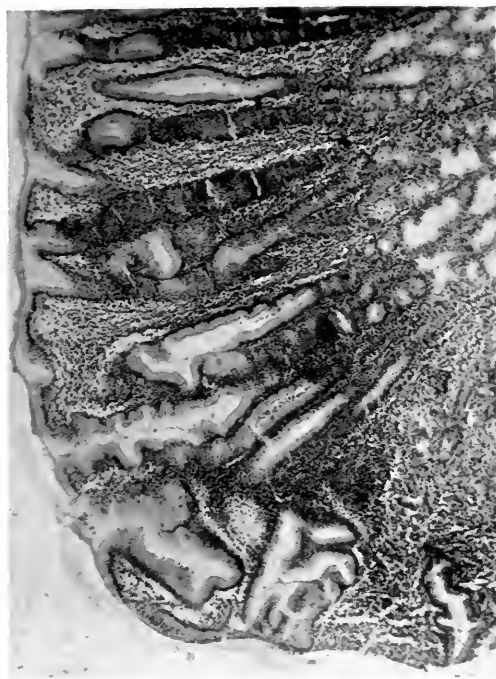


FIG. 15.—Specimen 26. Edge of ulcerated carcinoma showing carcinoma at "A" (x 80).



FIG. 16.—Specimen 26. Base of ulcerated carcinoma immediately adjacent to Fig. 15 (x 60).

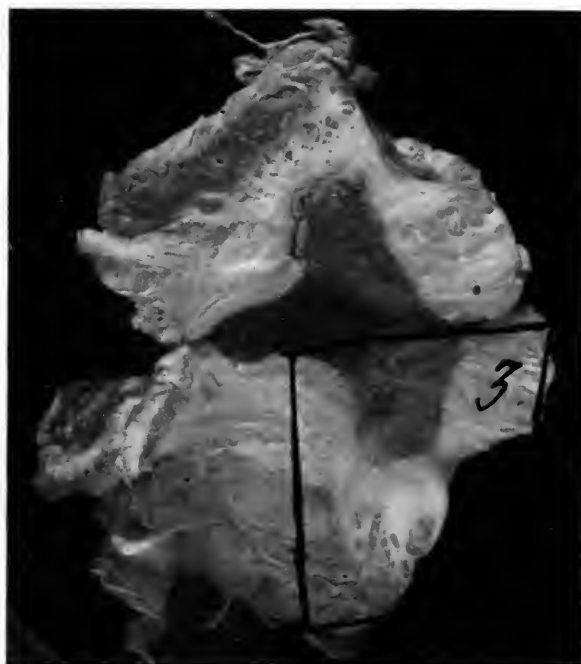


FIG. 17.—Specimen "U."

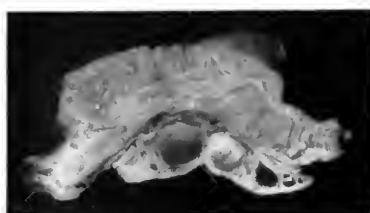


FIG. 18.—Healed ulcer showing cystic changes in mucosa.

## BENIGN ULCER AND CARCINOMA OF STOMACH

the lesion, is open to the same objection that the nature of the lesion is not determined accurately and the treatment is of dubious value if the pathological process is of carcinomatous origin.<sup>1</sup>

### SUMMARY

This investigation has not furnished absolute proof that carcinoma of the stomach can arise in a preëxisting ulcer, which was the problem under investigation. Evidence has been submitted which indicates in all probability that in one specimen out of the forty-eight examined there is present a carcinoma arising in an ulcer. This problem still needs further study, but from the results reported by others and from our own, it is fair to presume that in a very small percentage (1 to 2 per cent.) of ulcerated gastric lesions the morphological microscopical evidence indicates that carcinoma has arisen in an ulcer.

The majority of ulcerated gastric lesions, however, are either simple chronic ulcers or definite carcinomata. Any etiologic relationship of gastric ulcer to gastric carcinoma cannot be traced in these specimens.

Ulcerated gastric lesions which appear benign grossly were proved by the microscope to be malignant in 18.7 per cent. of the cases studied by us.

It is lesions of this sort which we believe have given rise to considerable confusion in the past. It is impossible to state whether they represent an ulcerating carcinoma or an ulcer which has undergone malignant transformation. The latter interpretation has been made by some investigators and this explains why some workers consider that a large percentage of chronic gastric ulcers show a carcinomatous change. We do not believe that this interpretation is justifiable, although these confusing lesions have a great significance so far as the surgical treatment of the ulcerated lesions of the stomach are concerned. The surgeon should therefore treat all of these lesions as though they were malignant tumors.

NOTE.—Most of the material was furnished by the Surgical Service of Dr. A. A. Berg. We are indebted to the kindness of Dr. W. Crump and Dr. J. W. Forbes, each for one specimen.

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<sup>1</sup> A local excision of these lesions when there is no metastatic involvement of lymphnodes at a distance of two centimetres beyond the ulcerated margin has been shown by the authors, in another investigation, to remove the entire local malignant process in at least the majority of the cases.

## AN IMPROVED MILITARY AMBULANCE

By GEORGE W. HAWLEY, M.D.

OF BRIDGEPORT, CONN.

ONE of the impressions one makes on coming in contact with the work of the "Service de santé" in France is the fact that no particular advance has been made in the matter of ambulance construction. As a rule, the familiar type of ambulance is used which has closed sides, supports for two tiers of stretchers, and doors opening in the rear. In addition provision is made for housing the stretchers against the roof and folding the stretcher supports out of the way, so that each ambulance may be converted into a 'bus with seats along the sides for the transfer of walking convalescent patients. In this way they are made to serve a double purpose.

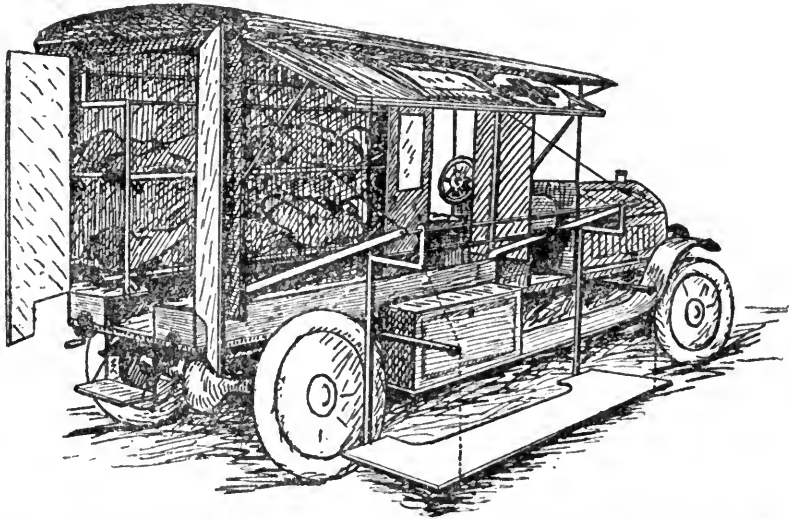


FIG. 1.—Perspective view of ambulance, showing side openings and swinging stretcher frame.

After watching the handling and transfer of large numbers of wounded men one is struck by the extraordinary amount of labor which is entailed. It requires at least three, and more often four, men to lift each stretcher high in the air as it is pushed end first into the ambulance. This is repeated four times for each ambulance.

In order to do away with the unnecessary labor and to substitute a simple for a clumsy method of loading, I have designed an ambulance body (Figs. 1 and 2) which loads from the side by means of a swinging frame. This frame is raised and lowered by a crank at the rear of the ambulance. When the frame is lowered it hangs by the side of the car and close to the ground, where two men can easily place the stretchers on the frame with-

## AN IMPROVED MILITARY AMBULANCE

out undue lifting. This in itself makes it possible to handle the wounded with less jarring and with more safety. With the stretchers in place the frame is raised into the ambulance and the side closed. A simple device locks the frame when housed. Provision has also been made to insure the lifting apparatus from accident.

A front door has also been supplied which makes it possible for the

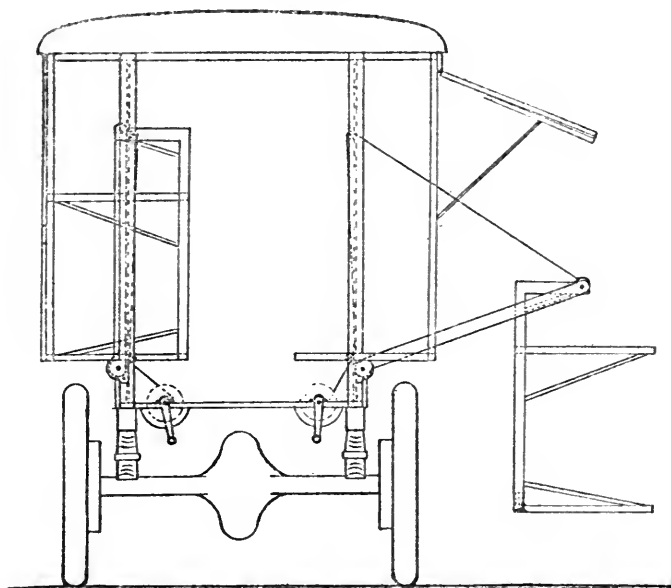


FIG. 2.—Rear elevation of ambulance (diagrammatic), illustrating swinging frame with lowering and raising mechanism operated by crank.

attendants to care for the men without getting out of the ambulance. There is sufficient passageway between the stretchers for a person to walk, and with an electric light in the roof the surgeon is able to watch his passengers from the driver's seat.

The inside construction is such that this ambulance can be used as a 'bus without changing it in any way. The bottom of the two swinging frames acts as long side seats.

# TRANSACTIONS

OF THE

## NEW YORK SURGICAL SOCIETY

*Stated Meeting, held November 14, 1917*

DR. WILLIAM A. DOWNES, Vice-President, in the Chair

### WEBBED FINGERS

DR. W. S. SCHLEY presented two cases of webbed fingers, as follows:

CASE I.—Girl, age fifteen years, was admitted to hospital March 5, 1914, with congenital deformity of the left hand, all the fingers of which were fused; the nails of the index and middle fingers were fused in one large broad nail. Joints freely movable. No tenderness or pain in fingers. She complained of inability to grasp or pick up objects. Function greatly limited. X-ray showed the first metacarpal bone to be shorter than the fellow on the other side; the second one smaller but perfectly formed; the third very short and thick and imperfectly formed and the epiphysis united. The fourth is short but fairly well formed. Its epiphysis has united. The fifth is almost normal in size and shape and the epiphysis has not united. The phalanx of the thumb is almost normal in size and shape and the epiphysis for the first phalanx has not yet united. The first phalanx for the index finger is fairly well formed. The exact size and shape of the terminal phalanx is difficult to determine. The first phalanx of the middle finger is well formed and the second and third phalanges are partly formed. The first phalanx of the ring finger is well formed. The second phalanx is very short and almost rudimentary. The third phalanx is fairly well formed. In the little finger, the first phalanx is well formed and the second is very small and deformed and apparently fused with the terminal phalanx.

*First Operation*, March 6, 1914: Incision between thumb and index fingers. Skin edges approximated as far as possible without tension, remaining raw surfaces covered with graft (Thiersch). Grafts covered with rubber tissue and band splinted. Dressed eighth day. Complete union.

*Second Operation*, March 20, 1914: Incision between middle and ring fingers *carried down well in cleft* to heads of metacarpals without cutting intermetacarpal ligament. Skin edges sutured as far as they would come easily. Thiersch graft covered cleft and remaining raw area. Dressed seventh day. Complete union. Thus the hand was divided into three portions: Thumb, index and middle fingers, ring and little fingers. The result was so satisfactory to the patient that she refused further operation and was able to earn a living in a domestic capacity.



## LACERATED WOUND OF THE LEG

Skin grafting was done here, as the classic Didot-flap operation seemed to offer insufficient skin for complete covering and because it was thought that an incision carried unusually far down in the cleft and successfully grafted gave less tendency to later closure of the cleft and shortening of already short fingers.

CASE II.—A child, seven years of age, was admitted to hospital, August 23, 1917, with a congenital deformity of both hands. There was an almost complete web between the third and fourth fingers of the left hand. On other hand a similar condition exists, but to less extent, being only half the length of the fingers. X-ray showed no bony deformity. A similar operative procedure was done. An incision was carried well down cleft and primary graft.

These cases were shown as examples of *skin graft operation*. There seems less tendency to fuse at cleft than the Didot flap, but unless there is primary graft union there is more tendency to cicatrix.

## LACERATED WOUND OF THE LEG

DR. JAMES M. HITZROT presented a boy of five years who was run over by an automobile shortly before his admission to the New York Hospital, October 23, 1917.

On admission there was an extensive laceration on the outer aspect of the left leg which extended from the upper third of the thigh to below the knee. In this region the skin had been stripped away from the underlying tissue to the inner side of the thigh. There was laceration of the biceps and vastus externus, and the outer head of the gastrocnemius muscle. Street dirt was ground into the fat, muscle, the outer portion of the capsule of the knee-joint, and throughout the outer aspect of the wound.

About four hours after admission the child was taken to the operating room. After preliminary skin sterilization with iodine ( $3\frac{1}{2}$  per cent.), the wound was irrigated with 1 per cent. formalin solution for about ten minutes. This was neutralized by ten volume peroxide solution and the wound then washed out with normal saline solution. All street dirt was carefully cut away during the irrigation and the muscle and fascia into which the dirt was ground excised by sharp dissection. The wound was then closed by interrupted silkworm stitches, after making three drainage openings through the avulsed skin flap along the posterior surface of the thigh. These drains were removed after twenty-four hours. The child made an uninterrupted recovery and the wound healed by primary union. The only temperature reaction of any moment occurred as a result of the tetanus antitoxin given the day after the injury.

The case was shown to demonstrate the efficacy of formalin as a wound antiseptic and the neutralization of its action by peroxide as shown by Stewart of Minneapolis. Dr. Hitzrot stated that he had used this method in

five lacerated wounds and a few compound fractures with equal success. The penetrating power and antiseptic action of formalin is so far the most potent of any of the antiseptics. Its destructive action on the tissues apparently is completely neutralized by the peroxide as Stewart stated.

In wounds which are possible of immediate closure and in which antiseptics is desirable, formalin is to be carefully considered, especially if used in the above way, and in wounds in which immediate antiseptics is desirable, although not susceptible of immediate closure, formalin as an antiseptic must be given due consideration. Further than its use in the preliminary or early sterilization, it cannot be used over longer periods because of the irritating qualities and the danger of kidney irritation due to the constant absorption of small quantities of the antiseptic.

DR. WILLIAM C. LUSK said that in his hands for a number of years chinisol (oxy-quinoline-sulphate), used in the first-aid treatment of fresh traumatic wounds, had quite evidently a disinfectant action. When there was no tissue deprived of its vitality in these wounds, he expected primary union to quite generally take place following suture of the severed structures, if the latter had been repeatedly soured with the chinisol solution. At the present time, for the primary disinfection of wounds, he used an aqueous solution of chinisol of a strength of grs. iv to  $\text{ʒi}$ . He mentioned a single instance of its use in the case of the repair of an anal canal which had been torn completely through by impalement on a spike, the tear reaching to a height of about two inches, and extending backward into the sacral region. The patient had had a large movement of the bowels just before the operation. The last record of the condition of the wound, which was made by himself nine days after the operation, stated that on this day, after the bowels had been moved, the suture line of the anal canal appeared intact without fistula formation. The portion of the wound behind the suture line of the sphincters had been left open for drainage.

The Council on Pharmacy of the American Medical Association, while they accredited to chinisol powerful antiseptic properties, had condemned it as a disinfectant. Their tests of the germicidal efficiency of this drug, however, had been made in the bacteriological laboratory and not in wounds. Chinisol, in the strength used, was non-irritating to wounds and did not coagulate albumin.

#### RETROSTERNAL GOITRE

DR. NATHAN W. GREEN presented a woman, aged thirty-seven years, who was admitted to hospital September 23, 1917, complaining of hoarseness and a sense of pressure in the throat. No swelling of the thyroid was apparent.

Bronchoscopic examination showed the trachea flattened anterior-posteriorly about three inches from the rima glottidis. There was an apparent bulging in the posterior wall of the trachea which at first was thought to be a tumor, but later was found to be due to outside pressure. In the left main

## CICATRICAL STRICTURE OF ŒSOPHAGUS

bronchus was evidence of some inflammation. It was evident that there was pressure on the trachea from some outside growth (goitre small and retrosternal). Further than this, as the patient's head lay over the table in the Rose position, a small swelling was seen to appear from behind the sternal notch.

October 10, 1917, Doctor Green removed a small, round, symmetrical tumor, about the size of a small hen's egg, under local anæsthesia by a curved incision which was made low down over the thyroid. The patient was able to talk all through the operation, and upon pressure being relieved by the enucleation of the colloid cyst, which was posteriorly located in the isthmus, she expressed an immediate feeling of relief which persists to the present time. She was discharged on the eighth day after operation with a temperature of  $98.4^{\circ}$  and a pulse of 64.

DR. HOWARD LILIENTHAL called attention to a method of reaching retrosternal goitre when it is so large that it cannot be drawn up, by splitting the sternum from above down and then retracting the two halves laterally. This makes room enough for the introduction of one finger, which can then lift the goitre out. He cited a case in which he followed this procedure with remarkable success; he split the sternum (Milton's method) and then, according to the Sauerbruch method, cut it through horizontally on one side and got two fingers in easily; in this particular case there was a thyroidea ima artery which was seen, caught, and tied in the mediastinum.

DR. ROBERT T. MORRIS cited an instance of difficulty in ligating the thyroidea ima artery in a case of retrosternal goitre where there was difficulty in ligating that artery because of its position behind the sternum. The resource consisted in slipping on a pair of forceps which were left in place on the artery for twenty-four hours, thus avoiding the complicated work of controlling hemorrhage in that situation by ligature.

## CICATRICAL STRICTURE OF ŒSOPHAGUS

DR. NATHAN W. GREEN presented a woman, forty-six years old, who, when eight years old, drank some fluid lye by mistake.

She was treated by an outside physician for a year, and then came to St. Luke's Hospital, where an Abbe string-cutting operating was performed by Dr. B. Farquhar Curtis. This relieved her for eight years. Then she again began to have difficulty in swallowing, and for the past four years, from 1912 to 1916, she had been back, having bougies passed by Doctor Virgin.

She was irregular in her visits, contrary to advice, and on April 24, 1916, the stricture had so closed that she could not swallow solid food; on April 27, 1916, she was unable to swallow fluids. She had lost weight and become anæmic and weakened. When finally admitted to the hospital, on April 29, 1916, the stricture was found to admit only a small filiform bougie. This was passed with the aid of the œsophagoscope. The stricture was then dilated to twenty-four French with bougies by Doctor Green. It appar-

ently was three or four inches in length and just above the cardia. On the ninth day of May she ran a temperature and had increase in fremitus, and the breath sounds were bronchovesicular from the angle of the scapula to the base of the left lung. On the thirteenth day of May, 1916, she ate solid food without discomfort, and her general condition was noted to be good. She was discharged from the hospital on that day, and returned occasionally for the passage of the bougie. She was readmitted on February 26, 1917, with again the complaint of difficulty in swallowing.

On February 28, under gas and ether anæsthesia, a gastrostomy was performed, excising the scar of the former wound and doing a Senn operation. On opening the abdomen, a few adhesions were found about the former gastrostomy opening. On March 14, under gas and ether anæsthesia, an attempt was made to pass the œsophagoscope from below to the stricture, and the cardiac end of the stomach was found, but the stricture could not be sufficiently dilated. On March 20 the patient had swallowed a string two days previously, and this string was brought out from the gastrostomy wound. The stricture had narrowed about the string, and a small bougie passed with difficulty. The string which had passed through the gastrostomy wound, the upper end being attached to the left ear, was tied to two strong, heavy cords, and these were pulled through the œsophagus, leaving both ends of each cord extending from the mouth and the stomach; to one of these cords was attached a small Billroth bougie which was pulled inside the stomach through the gastrostomy wound and into the stricture of the œsophagus; the other cord was then pulled back and forth with a sawing motion, and the Billroth bougie gradually advanced upward through the stricture; this bougie was withdrawn, and in turn larger bougies were similarly introduced and the sawing repeated until the maximum sized bougie (No. 41) was introduced; after the stricture was sawn with the cord, the bougie was left in place for several minutes; it was then withdrawn and a single cord left attached to the patient's left ear down through the œsophagus and out through the gastrostomy wound, to be used in further dilatation, if necessary; a large rubber tube was put in the gastrostomy wound.

After operation the patient ran a slight temperature for three days, which gradually subsided to normal.

The subsequent history is that the patient returned to the hospital for the passage of a No. 40 French bougie, at first once a week, then every two weeks, and latterly once a month. She has gained eighteen pounds since April 1, 1917.

Although she returns quite regularly, still the necessity of passing the bougie is demonstrated by the resistance to it by the stricture at each sitting. It shows the necessity of keeping up this dilatation for a long time, probably for years, at increasing intervals.

## EFFECT OF SPLENECTOMY

### SPLENECTOMY FOR PERNICIOUS ANÆMIA

DR. WILLIAM A. DOWNES presented a man, aged thirty-two years, who was admitted to St. Luke's Hospital, December 30, 1914, complaining of weakness, dizziness and roaring in head—five months' duration. Fainted one week ago. No previous illness. Examination showed a fairly well-developed and nourished man; with liver slightly enlarged; spleen not felt.

*Blood.*—White blood cells, 7500; polymorphonuclears, 70; lymphocytes, 30; red blood cells, 1,500,000; hæmoglobin, 30 per cent.; 1 megaloblast, 2 normoblasts, 1 myelocyte, polychromatophilia and stippling. Blood culture negative. Wassermann negative. Stool negative for parasites. Stool negative for blood.

January 11, 1915: Blood transfusion was done. Blood examination after transfusion showed 4,000,000 reds and 70 per cent. hæmoglobin. January 18, 1915, splenectomy was done. February 3, 1915, red blood cells, 4,000,000; hæmoglobin, 55 per cent.; white blood cells, 9500; polymorphonuclears, 74; lymphocytes, 26.

*Blood Examination*, February 18, 1915.—Red blood cells, 4,200,000; hæmoglobin, 75 per cent.

*Pathological Report.*—Spleen measures  $12 \times 8 \times 3$  cm.

*Microscopic Examination.*—Fibrosis and lymphoid hyperplasia.

*Blood Examination*, November 14, 1917.—Red blood cells, 4,500,000; white blood cells, 18,000; hæmoglobin, 100 per cent.; polymorphonuclears, 65; lymphocytes, 35; no abnormal cells.

He has followed his vocation as an embalmer for the past two and one-half years without interruption. He feels as well as ever in his life, and has had no treatment since discharge from the hospital February 20, 1915.

## EFFECT OF SPLENECTOMY

DR. JAMES M. HITZROT read a paper entitled "The Effect of Splenectomy on the Normal Individual and in Certain Pathological Conditions, with Illustrative Cases."

Dr. Hitzrot also showed a case of traumatic rupture of the spleen in a boy aged fourteen, who was admitted to the New York Hospital on September 11, 1913, with a history of having been thrown from a truck about four hours before admission. The operation was done a little over four years ago and the patient has grown and developed normally.

Doctor Hitzrot showed a second case of splenectomy. The operation was done for acholuric jaundice in a woman of twenty-seven years, three and one-half years ago. She is now entirely well and free from the symptoms which existed before the operation. Her blood count on November 12, 1917, was: red blood cells, 3,250,000; hæmoglobin, 87 per cent.; leucocytes, 18,600; polymorphonuclears, 86 per cent.

Doctor Hitzrot showed a third case of splenectomy, which was done for pernicious anæmia in a man of thirty-seven years, six months ago.

The man is now entirely well and free from the weakness, etc., which

existed before the operation. He has gained seventy-eight pounds in weight and his blood count on October 5, 1917, was: red blood cells, 5,200,000; hæmoglobin, 80 per cent.; leucocytes, 11,200; polymorphonuclears, 52 per cent. The case was one in which the anæmia was due to some sort of hæmolysis or an hæmatogenous crisis, and like the case presented by Doctor Downes, has shown a marked improvement since the removal of the spleen. It is yet too early to predict the outcome of the case, but Doctor Hitzrot believes that it was in this type of pernicious anæmia in which splenectomy was indicated and in which the removal of the spleen seemingly improved and sometimes cured the patient.

DR. HOWARD LILIENTHAL cited fourteen cases of splenectomy, of which three were for Banti's disease, and one was combined with rather an unusual extent of traumatic rupture of the spleen. In this case the spleen weighed four pounds, was degenerated and was pronounced by the laboratory of Mt. Sinai Hospital to be a case of Banti's disease. The patient, a girl of fourteen, fell, striking her abdomen against the curbstone, soon after going into profound shock. The following day at the time of operation the abdomen was found filled with blood and serum, and when the operator (Doctor Lilienthal), not knowing that it was a ruptured spleen with which he was dealing, tried to peel away what he thought was an adhesion, he found this was the omentum which had glued down the rent in the spleen; there followed a terrific hemorrhage and the spleen was immediately removed. The patient is now in perfect health with a normal blood picture. Another splenectomy, for Gaucher's disease, was in a woman of forty-five, in whose case the spleen weighed about 13½ pounds. The patient was a very small woman, and only complained of pains in her legs. Her liver was ptosed into the pelvis. Operation in this case has been followed by a perfect recovery.

Doctor Lilienthal then referred to another case the diagnosis of which had always been doubtful in his mind. A man came to him with a history of having been jaundiced for some years. He had had repeated attacks of biliary colic; Doctor Einhorn said he had gall-stones. Doctor Lilienthal, in his otherwise careful examination failed to have a blood examination made, as he did not consider it anything other than a case of gall-stones. On operation no gall-stones were found; a cholecystotomy was done in the hope of relieving the jaundice, then a search was made in the direction of the common duct where something was felt that was believed to be a chain of stones in the common duct. When a needle was inserted pure blood oozed out and it was found that the supposed stones were calcified plates in the portal vein. The case was doubtless one of blood jaundice or perhaps of Banti's disease. The patient died soon after of recurrent hemorrhages. No autopsy.

Doctor Lilienthal then discussed the technic of splenectomy, calling attention to the difficult cases in which the spleen is adherent to the diaphragm,

and in which its removal is impossible. In order to be sure and save the hundredth patient every precaution should be taken in every case in which the spleen is to be removed where there is any question as to the mobility of the organ. First of all the question of blood transfusion before operation: this is not to be done unless the patient is decidedly anæmic; if the hæmoglobin is in the 20's a blood transfusion is indicated before operation. If the spleen is large and the patient not very anæmic the tendency should be rather to have the donor ready and the transfusion done following operation if necessary. Doctor Lilienthal, in preparing a patient for splenectomy, always makes use of tourniquets around the thighs. The blood-pressure should be carefully taken before the tourniquets are applied and again just before the operation; there will be found a very great diminution in the blood-pressure by this method. In a normal person it has been possible to reduce the blood-pressure 60 mm. Hg. If shock or hemorrhage accompany the operation, the tourniquet should be removed from one leg and this will save the necessity for transfusion, and it will also prevent a large amount of hemorrhage. The question of the incision is of secondary importance. It is all right to begin with the sagittal; if formidable adhesions in the upper abdomen make it impossible to work through this opening it is suggested that another incision connected with the tip of the sagittal incision and running down along the border of the ribs be made. This has been criticised as dividing the nerves, but although this criticism is true the speaker has never seen an atrophy resulting, and the wounds have healed beautifully, and one can get as near as possible to the place of greatest danger, the region of the diaphragm. Evidently the intercostal nerves reunite. If the adhesions are to a movable organ, the case is comparatively simple, but if they are attached to the diaphragm it is necessary to have an opening big enough to get two hands in and work under the eye, thus restricting hemorrhage. Doctor Lilienthal stated that he had made the foregoing incision in seven cases and wished to recommend it highly.

DR. NATHAN W. GREEN stated that he had been asked to see a case in consultation of a man who had been going through an attack of paratyphoid fever; the temperature had dropped, then started to climb again and he had an enlarged spleen with great tenderness over it. He was asked to see this case in the hope that he would do a splenectomy and was told by the house physician that abscess of the spleen was found in 40 per cent. of all paratyphoid cases coming to autopsy. In this case no operation was performed and two weeks later the spleen was steadily diminishing in size, tenderness was disappearing, and temperature was coming down.

DR. WILLIAM A. DOWNES, in replying to a query, stated that from his experience, which was based on eight cases, he believed that some cases of pernicious anæmia were benefited by splenectomy, others not at all. He considered that he had made a mistake in two or three of his cases, operating where the disease had progressed so far that it proved of no real advantage.

## DUODENAL LEAKAGE THROUGH THE COMMON DUCT

DR. JAMES M. HITZROT showed a specimen removed at autopsy of duodenal leakage through the common duct. The patient, a woman of fifty-four, was admitted to the New York Hospital, First Surgical Division, September 5, 1917, complaining of pain in the right hypochondrium which began as sharp severe colic in the upper abdomen, especially on the right side, and which radiated into the back. She vomited. She has had five similar attacks since an operation done in November, 1916, at which time a drainage operation, with the removal of a number of stones from the gall-bladder, was done by another surgeon. These latter attacks have all been similar in character to those which preceded the first operation. Patient has not been jaundiced except on one occasion before the first operation. On admission, patient was slightly jaundiced. The abdomen was distended and there was tenderness with rigidity over the whole upper right half of the abdomen, most marked in the region of the previous operation. Her temperature was  $97.4^{\circ}$ , leucocytes, 17,500; the urine contained a few white blood cells, no casts, and epithelial cells.

On September 7, 1917, under gas and ether, a cholecystectomy, choledochotomy and transduodenal choledochotomy was done through a six-inch hockey-stick incision. On opening the abdomen the omentum, stomach, and liver were all plastered together against the parietal peritoneal wall in a dense mass of adhesions which were freed with considerable difficulty. The gall-bladder was exposed, and found to be markedly thickened and to contain a few stones. The common duct was enormously dilated and stones could be felt in the hepatic duct from the liver down through the common duct clear to the ampulla, where there was a mass of very hard stones which were distinguished with difficulty from the nodular enlargement of the head of the pancreas. The gall-bladder was excised. The common duct was opened and perhaps a dozen or more stones with a lot of biliary sand removed; part of the stones being brought down from the hepatic duct and part from the duct in the wall of the duodenum. After these stones were removed one stone was found high up in the hepatic duct, and was dislodged from the liver with considerable difficulty. One stone was likewise lodged in the ampulla and after considerable manipulation was squeezed out through the opening in the duct. After this was done, a hard mass was felt slightly to the left of the probe in the common duct, which could not be dislodged. A bent probe was then passed into this region, and there was a distinct click as if striking a stone. A transverse duodenal choledochotomy was then done and the duct opened through the posterior wall of the duodenum at the ampulla and a dilated portion of the duct, almost a diverticulum, opened and from this three stones were removed. The opening was partially closed with chromic catgut and the opening in the duodenum closed with three rows of chromic stitches, the last stitch fastening a piece of the omentum to cover the outer row of stitches. A rubber tube was then passed into the dilated common duct and fastened



## REMOVAL OF CANCER OF STOMACH

into position with one suture and the duct closed about it. Three cigarette drains and one rubber-dam drain were placed about the stump of the gall-bladder, in the gall-bladder fossa and in Morrison's pouch and behind the duodenum. The wound was then closed in layers, using double-loop silk-worm tension stitches.

The patient made a satisfactory convalescence. The drains from about the tube in the duct were removed on the sixth day. On the seventh day there was a profuse watery drainage from the wound. Methylene blue given by mouth appeared in the wound secretion between forty-five minutes and one hour. This discharge increased on the next two days and food and fluid by mouth was stopped and rectal fluid given. The patient, however, never improved sufficiently to permit of an operative investigation and died eleven days after the operation. The natural supposition was that the duodenal wound had leaked.

A partial autopsy by Doctor Spencer showed that the leakage had occurred through the opening in the common duct, and that the anterior duodenal suture line was intact. The specimen exhibited showed that the mucosa about the opening in the ampulla had ulcerated where it had been closed by suture, leaving an opening about 0.75 cm. in diameter in the wall of the duodenum communicating with the dilated common duct. Leakage had occurred through this opening into the duct and out through the drainage opening in the common duct. In retrospect, Doctor Hitzrot felt that it would have been difficult to have met this condition by a second operation, and showed the specimen to demonstrate a serious complication of transduodenal choledochotomy when dealing with a large dilated common duct.

*Stated Meeting, Held December 12, 1917*

DR. WILLIAM A. DOWNES, Vice-President, in the Chair

### LONG FREEDOM FROM RECURRENCE AFTER REMOVAL OF CANCER OF STOMACH

DR. JOHN DOUGLAS presented a man, thirty-five years old, upon whom he had performed a resection of the pylorus together with a resection of a portion of the liver to which the carcinomatous ulcer was adherent, five years ago. The operation was performed on November 28, 1912. Symptoms of ulcer were present for twenty months previous to operation. The lesion found was a large callous ulcer of the lesser curvature which had perforated and become adherent to the liver. Radiographic examination demonstrated a typical hour-glass stomach. Pathological examination of the specimen showed carcinoma developing in an old ulcer.

The particular points of interest in this case were the age of the patient in whom carcinoma had developed (thirty years), the technical difficulty of the resection, necessitating the removal of a wedge-shaped portion of the liver, and the evidence of old perforation closed by adhesions to the liver, and the fact that he was alive and well five years after operation.

Doctor Douglas also presented a woman, aged fifty-eight, upon whom he had performed a pylorotomy by the Bilioth No. 2 method, for carcinoma on April 19, 1912, five years and eight months ago. Her gastric symptoms had been present for two years, and a movable tumor eight to nine centimetres in diameter could be felt in the epigastric region. The pathological report was scirrhus carcinoma of the stomach.

The particular interest in this case lay in the fact that although the patient states that her tumor had been present for eighteen months previous to the operation, there was no glandular metastasis, and the operation was not technically difficult.

Doctor Douglas had done eleven resections of the stomach for carcinoma, nine being pylorotomies. Of the nine pylorotomies four are still alive, the two cases shown (one five years and eight months, and the other five years ago) and two others, one five years and two months (an old lady who is now seventy-five years old), and one sixteen months. Two died as an immediate result of operation, one from gangrene of the leg, and one from what Doctor Douglas believed was heat stroke; the others lived from six to seventeen months after operation.

Friedenwald stated that out of two hundred and sixty-six of his own cases of carcinoma of the stomach not a single one was alive, and Peck in his analysis of five hundred and twenty-seven cases admitted to the surgical services of several large New York hospitals in the last five or six years, could find records of but thirty-three in which radical operation had been performed, of whom only twenty-three recovered, of which small number but eight were known to be alive and well. Three of the cases were at four years, one at two years and six months, and the others at shorter periods. Therefore these cases are presented, which with the other two cases he reported makes a somewhat less gloomy prognosis for a limited number of cases.

DR. GEORGE WOOLSEY called attention to the long period of time which had elapsed in both these patients and considered these very encouraging cases. He referred to two of his own cases, well four years or over, out of eighteen cases resected, of which the mortality was one. He considered that the variety of the tumor and the presence or absence of glandular metastasis had much to do with the prognosis. Glandular metastasis occurs late, and in many cases some or all enlarged glands are not carcinomatous.

DR. WILLY MEYER considered it important to differentiate between cases of carcinoma of the stomach of primary origin and carcinomatous degeneration of an ulcer. He stated that it was his belief that a carcinoma occurring on the borders of an ulcer was often less virulent than one occurring in the base of an ulcer. He recalled only one case of primary carcinoma of the stomach well more than ten years and referred to two occurring in the borders of old ulcers well for more than three years. He described one case of carcinoma developing in the base of an old ulcer in which operation prolonged life but a short time, due to the inability to perform a sufficiently

## STONE IN SOLITARY KIDNEY

radical removal. The transverse mesocolon had been invaded and the patient appeared too weak to stand the operation. Clearly indicated: Simultaneous resection of stomach and transverse colon.

DR. PARKER SYMS asked if there was anything in the pathological findings of these cases which would indicate the existence of a previous ulcer. There seemed to be a history of gastric symptoms extending over periods of two years or more.

DR. JOHN DOUGLAS, in closing, answered Doctor Syms' query by stating that in the second case reported the patient unquestionably had an ulcer of the lesser curvature existing for at least two years and which had perforated, causing adhesions to the liver which were so extensive that it was necessary to remove a portion of the liver with the pylorus and a portion of the stomach. He referred to a patient whose case was reported before the Society a year ago who is still alive seventeen months after operation; in this case the tumor mass was also adherent to the liver, making it necessary to remove a considerable piece of the liver; microscopical examination showed the liver cells involved with the carcinoma. He considered in this case that it was a difficult matter to state whether or not the original condition was that of ulcer. He considered this case particularly interesting from this viewpoint, as there was a history going back only three months previous to operation, no vomiting, no pain, and only symptoms of indigestion before the tumor could be easily felt in the epigastric region. In the case of the woman presented at the present meeting there was a history of a tumor of which she had herself been conscious for eighteen months with no glandular involvement; there were enlarged glands but these were not carcinomatous.

In consideration of Doctor Meyer's point as to the difference of malignancy in tumors originating in gastric ulcers and those primarily carcinomatous, Doctor Douglas felt that this differentiation was extremely difficult. He recalled a case of a woman who had a large tumor at the pylorus diagnosed as carcinoma, and which was resected for this reason, in which the microscopical examination proved the condition to be one of indurated ulcer, not carcinomatous.

## STONE IN SOLITARY KIDNEY: ANURIA

DR. JOHN DOUGLAS showed a woman, thirty-two years old, admitted to St. Luke's Hospital, August 21, 1917. She states that she had a sister born with only one arm. The patient had an operation on her left appendages in another hospital nine years ago. She had an attack of renal colic on the right side seven years ago, and passed a stone from the bladder. Three years ago she had another attack of renal colic on the right side and had a radiograph taken which was negative. The following day she passed the stone.

Ten days before admission she had hæmaturia. Three days before admission she had right renal colic. Had passed no urine since day before admission. Examination showed tenderness in right costovertebral angle. No urine in bladder. X-ray catheter passed by Doctor DuBois 25 cm. No

flow of urine. No ureteral orifice found on left side. Anuria continued and uremic symptoms appeared and operation was done, with a diagnosis of stone in a solitary kidney. The kidney was exposed by a posterior incision. It was found to be almost twice the normal size and a small, conical-shaped stone was found tightly plugging the junction of the pelvis and the ureter. Convalescence uneventful. Subsequent cystoscopy with a Garceau catheter by Doctor DuBois at the hospital confirms the absence of a left ureteral orifice.

DR. WILLY MEYER referred to a patient, a young woman in whom he had done a nephrectomy for a large suppurating kidney, operated in 1892. A week subsequent to the operation the patient suddenly had total anuria. Forty-eight hours after onset of the symptoms a lumbar incision was made, the pelvis of the remaining kidney found very much enlarged and the ureter totally blocked, not by a stone but by a peculiar soft gelatinous material similar to that which had been found in the opposite kidney. Masses of this material were removed with a spoon from the pelvis, and then a catheter was passed into the ureter, washing the obstructing material out with a syringe in a retrograde way. The patient recovered from the condition and is alive to-day.

DR. WILLIAM A. DOWNES called attention to the inability to diagnose a condition of solitary kidney exclusively upon failure to find the ureteral opening and referred to a case of tuberculous kidney where no opening could be found on the right side, but where, after making a median, anterior incision, a well developed right kidney, probably the original focus of the tuberculosis, was found. This kidney was perhaps half the normal size, and at the juncture of the ureter with the bladder there was a mass the size of an olive, completely blocking the ureter. Eight or ten attempts had been unsuccessful in locating the opening.

#### BRANCHIOGENETIC CYST WITH SINUS LEADING INTO PHARYNX

DR. JOHN DOUGLAS showed a girl who at birth had a small tumor about the size of an almond on the right side of the neck just above the clavicle at the inner margin of the sternomastoid. This had been operated on when she was ten months old, but had after two years returned. Since then it had opened at frequent intervals and discharged. At the time of operation the sinus was closed and the cyst was about 2 x 3 cm. in diameter. When the cyst was dissected out it was found that it was pyriform in shape, its apex being connected with a prolongation formed by a sinus running upward. This was traced upward and dissected out, a second incision being made beneath the lower jaw. It was found that the sinus connected with the pharynx just beneath the tonsil. The sinus was cut about 4 cm. from the pharynx and a probe inserted to facilitate dissection, and, when freed to its upper level, the lower end was tied to the probe which was pushed through the pharyngeal mucous membrane, and the remainder of the sinus pulled into the pharynx. It pulled off at the level of the mucous

## FASCIAL TRANSPLANT IN HERNIOTOMY

membrane, the opening in which was then closed by a couple of chromic catgut sutures.

DR. DOWD presented a similar case before the Society about a year ago, when he stated that it was the first case of this kind reported before the Society. In his case, however, while it was due to a failure of closure of the second branchial cleft, there was complete fistula. In this case both ends of the tract were closed, although there was a completely patent sinus between them.

DR. DOUGLAS added that within the past three days he had seen a man about forty-five years old, who, by holding the mouth and nostrils shut, and blowing hard, could distend the right side of his neck with air, which, when pressed on afterwards, could be emptied into the pharynx with a gurgling sound. Evidently this was due to an opening of the inner end of a branchio-genetic sinus into the pharynx.

## ACQUIRED DEFECT OF THE URETHRA

DR. JOHN DOUGLAS presented a patient with an *acquired defect of the urethra*, for which he had been rejected for enlistment in the U. S. Navy. The patient stated that this lesion had been present as long as he could remember, and as his parents had been dead for several years no history as to how it had been caused could be ascertained.

There was present a defect in the floor of the urethra about .7 cm. long, located about 3 cm. behind the meatus. There was present the scar of a circumcision and also evidence that sloughing had occurred, probably caused by a paraphimosis. This had caused a loss of tissue in the anterior portion of the left corpus cavernosum, a lesser defect in the right corpus cavernosum, with a destruction of most of the urethra at this level, except on its roof, as evidenced by a small strip of mucous membrane about .2 cm. wide and .7 cm. long when separated.

Under anæsthesia, a posterior urethrotomy was done. Then after a meatotomy it was found that graduated sounds up to a 30 French could be passed from the meatus to the bladder. A transverse incision through the old scar was made, and the ends of the damaged urethra were dissected out and sutured end-to-end, with fine chromic catgut. This line of suture was reinforced by a second layer formed by the sheath of the corpus spongiosum, and the skin incision closed. The catheter inserted into the external urethrotomy opening was removed on the seventh day, and on the following day the urine passed by the meatus. There was slight leakage through one of the stitch holes for a few days, but this soon ceased.

## FASCIAL TRANSPLANT IN HERNIOTOMY

DR. IRVING S. HAYNES presented a man, aged forty-seven years, who came under his care at the Park Hospital in October, 1917, for an inguinal protrusion on the left side. This region had been operated upon four times

during the previous ten years, as follows: The hernia first appeared about ten years ago and it was operated then and remained cured until twenty months ago, when, after lifting a heavy weight, it returned. A second operation was performed eighteen months ago. At this time the right side was also repaired. Spontaneous recurrence took place in the left side in about a week. A third operation was performed about a year ago. A hæmatoma formed, was infected, and recovery was slow, by the usual process of granulation. A cure was apparently secured. In about three weeks the hernia returned in the old scar, on the left side. A fourth operation was done about eight months ago. Healing was uneventful. There was a cure for about five months, when again a hernial protrusion was noticed.

Examination showed scars in both inguinal regions. The right side was sound. On the left side, at the lower end of the incisions and at the site of the external inguinal ring was a small protrusion about the size of half a hen's egg, that gave an impulse on coughing and disappeared when he lay down. A finger could be passed into the external ring and there seemed to be no posterior wall to the inguinal canal.

With this region the seat of four preceding operations, it was certainly a problem as to what to do that would give the best chance for a cure. He determined to apply the fascial transplant to the inside of the inguinal region so as to completely cover this area, especially the weak spot. At operation he made a transverse incision about 6 inches long above the symphysis by which the region of the external inguinal ring was bared. A vertical incision was then made in the mid-line to the properitoneal fat. This was thoroughly stripped off from the inside of the inguinal region, so that the deep epigastric vessels and the spermatic cord were thoroughly exposed. The weak region at the site of the external ring was apparent. From the right thigh a strip of fascia, 3 x 6 inches, was taken. With the patient in a high Trendelenberg position, and with strong retraction of the wound, the flap of fascia was sutured over the inguinal region. The cord and vessels were overlapped at the outside and the flap was fastened by sutures, tied after the wound was allowed to close, so that the graft extended across the mid-line to the opposite inner surface of the abdominal wall. Under the guidance of eye and fingers three mattress sutures of kangaroo tendon were placed to approximate the margins of the weak area, which was about an inch in diameter. The recti muscles were sutured together with plain gut, the fascia with interrupted chromic, reinforced by silkworm retention sutures and the skin closed with silkworm. A small drain of rubber tissue was brought out of the right angle of the skin incision. There was considerable drainage of liquid fat and serum for a week, but the abdominal and thigh wounds united by primary union. The patient was kept in bed for three weeks and then was permitted to sit up for short periods and not allowed to get out of bed until the fourth week.

At this date the abdominal wall seems perfectly solid. Œdema of the testicle and scrotum was expected but none followed.

## SPLENECTOMY FOR SPLENOMEGALY

DR. JOHN F. ERDMAN stated that he had done the fourth operation on this man, the three previous ones having been done by Doctor Moorehead. He stated that he had made a very wide resection from behind the internal ring and inverted the fascia after the method of Doctor Haynes. He had been unable at first to recognize the cord. He finally found the vas, etc., and after the method of Bassini closed the wound. He suggested that a later presentation of this patient, say in three to six months, would be of interest to all.

DR. ALEXIS V. MOSCHCOWITZ stated that he believed he held the record for multiple recurrences, having operated one patient who had been operated eight times at other institutions. He suggested the possibility of curing such a tendency to recurrence as in the case of Doctor Haynes by castration of the individual, which would permit of complete closure of the opening on the affected side, and would not be quite as complicated a procedure as the one adopted by Doctor Haynes.

## SPLENECTOMY FOR SPLENOMEGALY

DR. IRVING S. HAYNES presented a man, aged forty-eight years, who was under his care at the Park Hospital in October, 1917. As a boy, the man had suffered a prolonged attack of dysentery. At the age of twelve he had an attack of yellow fever in the West Indies. For the past thirty years has lived in the North, during which time he had had several attacks of malarial fever, the last one twenty-two years ago. Had an attack of pleurisy two years ago. Eight weeks ago began to suffer from pain in the small of his back and in the right hip. Following the first attack of this pain, he began to suffer from pain in the left hypochondrium, which has increased. Upon examination, there is a mass to be felt in the left hypochondrium. Wassermann examination negative. On October 9, 1917, the abdomen was opened by a transverse incision six inches long above the level of the umbilicus, dividing the rectus and the abdominal wall. Nothing abnormal was found excepting the spleen three times the normal size studded with multiple cysts. Everywhere these cysts were present, the spleen was firmly adherent to the adjacent surface. Owing to these adhesions the removal of the spleen was made difficult, but it was, nevertheless, speedily accomplished. Free oozing followed the separation of the adhesions, for the arrest of which a large hot pack was placed in the splenic bed and the wound closed. The pathological examination showed the cystic nodules to have been degenerated infarcts of the anæmic type. Throughout the spleen there are disseminated other typical old and recent infarcts. The rest of the spleen pulp shows deeply pigmented cells here and there with increased thickness of trabeculae and hyperplastic malpighian corpuscles. The patient made an uninterrupted operative recovery and left the hospital at the end of the third week after operation. Blood examination made six weeks after operation showed red cells, 4,800,000; white cells, 14,000; polymorphonuclears, 60 per cent.; small lymphocytes, 32 per cent.; large lymphocytes, 8 per cent.

## HERNIA FOLLOWING TRANSVERSE ABDOMINAL INCISION

DR. IRVING S. HAYNES presented a man, aged forty-three years, who was under his care in the Harlem Hospital from October 22 to December 10, 1917. He had been operated by one of his colleagues in the preceding April for gastric ulcer, to expose which a transverse incision had been made across the right side of the abdomen about two inches above the umbilicus, extending outward six inches from the mid-line. The patient had been a sufferer from asthma due to chronic pulmonary emphysema for many years. After the operation he suffered very severely from aggravation of his asthmatic condition, coughing continually. After this pulmonary condition had been controlled, the wound healed and he remained in perfect health until September, when he noticed a bulging in the inner end of the scar, which rapidly enlarged until it had attained the size of an orange, when he entered the Harlem Hospital again on October 22. The hernial weakness included the entire scar from the previous operation, margins of the hernia forming an ellipse six by three inches in diameter. On November 1 he was subjected, by Doctor Haynes, to operation, in which his inversion technic was carried out. The skin over the hernia in a mass 8 x 4 inches was removed by an elliptical incision. The surface of the fascia from 2½ to 3 inches beyond the margins of the hernial opening was denuded; also the surface of the hernial sac. The margins of the hernial orifice were approximated by mattress sutures of medium sized kangaroo tendon inserted through the muscle edges. When these were tied, the hernial sac was inverted and the margins of the opening closely approximated and inverted into the abdomen. A second row of mattress sutures of the same material were then placed about one inch outside of the first row. As these were tied, the preceding suture line was inverted with the margins of muscle adjacent to the hernial opening. The musculo-cutaneous opening was then closed by three figure-of-eight wire sutures inserted deeply into the muscles about an inch outside of the second row of kangaroo tendon sutures. When these wire sutures were twisted over separate rolls of gauze, the previous lines of sutures were still further inverted. A subcuticular drain of rubber tissue was then placed *in situ* and the skin margins sutured with black silk.

Post-operative course: During the first week the patient was troubled with asthmatic attacks. On the eleventh day the rubber tissue drain was removed. On the thirteenth day the skin sutures were removed. On the seventeenth day two of the wire sutures were removed, the remaining one removed two days later. Patient was permitted to get out of bed on the twenty-fourth day, and returned home on the thirty-first day, with the hernia apparently permanently cured.

Doctor Haynes remarked that the type of operation used in this case was one that he began using in 1911 and had continued to employ ever since in post-operative hernia, especially those of unusual size. The steps of the operation had been first described by him in the *New York State Journal of Medicine*, in December, 1913.



## TETANUS FOLLOWING FRACTURE OF ULNA

### HERNIA RECURRING AFTER MACEWEN OPERATION

DR. ALEXIS V. MOSCHCOWITZ presented a patient who was operated by him for a recurrent inguinal hernia. The interest in the case centred around the fact that the original operation took place thirty-three years ago, at which period MacEwen's operation was the operation of choice. He wore a truss ever since his operation, but discarded it about four months ago, whereupon the hernia promptly recurred. The sac of the recurrent hernia showed a sort of fibrous ring at its neck, where it was apparently tied off; and in various other parts of the sac there were to be seen a number of cicatrices, just at those points where it was reefed in order to make the pad required for the MacEwen operation. Poupart's ligament and most of the other structures were, as might be expected, untouched.

### TETANUS FOLLOWING UPON A FRACTURE OF THE ULNA AND DISLOCATION OF THE HEAD OF THE RADIUS

DR. ALEXIS V. MOSCHCOWITZ presented a boy, seven years of age, who had been admitted to his service at Mt. Sinai Hospital April 11, 1917, with the history that one week ago he fell off a fence and injured his right forearm. Two days ago the arm became swollen, and this swelling was incised by his physician, under the supposition that it was an abscess. On admission there was found a large fusiform swelling surrounding the right elbow-joint; one and one-half inches below the elbow-joint there was an incised, infected wound, discharging a small amount of pus. The entire area was extremely tender, particularly over the ulnar aspect, where crepitus was also obtained. A prophylactic injection of 3000 units tetanus antitoxin (New York Board of Health) was given immediately on admission, and the arm put up with traction in extension.

On April 16, five days after admission, it was noted that the facies was suggestive of a risus sardonicus; the jaws could still be separated however. All reflexes were very active. All the muscles, particularly those of the back and abdomen, were rigidly contracted. Tetanic spasms of short duration occurred. Six thousand units of antitoxin were given. The usual treatment with bromides and morphine was also indicated. On the following day, April 17, the general condition was much worse. The jaws could be barely separated; one convulsion of three minutes' duration and several slight ones occurred.

Six thousand units antitoxin were then given subcutaneously, and in addition also 6000 units intraspinally, after a withdrawal of 30 c.c. spinal fluid. No tetanus bacilli were recovered from the wound culture, and mice injected with the spinal fluid on this and subsequent occasions all survived.

The condition was even worse on the following day, April 18. In the morning of this day 6000 units of antitoxin were administered intraspinally, without any notable effect. In the afternoon 2 c.c. of a 25 per cent. magnesium sulphate solution were injected intraspinally; whereupon the follow-

ing reaction was noted. The respirations became slower and occasionally there was also a sighing and yawning. For the first one and one-half hours the pulse was quite irregular. There was a complete relaxation of the entire musculature and no convulsions occurred, not even after artificial stimulation, which previous to injection always proved to do so. Three hours after the injection both the pulse and respirations were perfectly normal.

Slow improvement began with this one injection. We continued with the magnesium sulphate hypodermically, 1 c.c. being given every six hours. We also continued with the administration of antitoxin and antispasmodics. The symptom last to disappear was the one to appear first, namely, a local contraction of the right biceps upon the slightest irritation. All treatment as far as the tetanus is concerned was discontinued April 26, after the appearance of a very profuse urticaria. Thus far the gravity of the case prevented much attention being paid to the injured arm. As already stated, the fractured ulna was treated by extension and traction.

On May 1 examination revealed a more or less malunited fracture of the ulna in its middle, and a forward dislocation of the head of the radius. On May 2 an unsuccessful attempt at reduction of the dislocation was made by Doctor Brickner. The question now arose how soon it would be safe to operate for the dislocation of the radius without possibly stirring up dormant tetanus bacilli. It was decided to postpone operation for the time being. He was readmitted June 23; operation June 26, the head of the radius being resected. He was discharged cured July 7.

DR. WINFIELD S. SCHLEY referred to a case reported by him in 1904 of tetanus following a punctured wound just below the knee in a small boy, developing five days after the injury. At that time magnesium sulphate was not one of the adjuncts to the treatment, but intraneural, intraspinal, and subcutaneous injections of serum were used. The intraneural injections were very helpful; the spinal injections were subdural, not into the cord, the patient receiving altogether about 200 c.c. of serum. He made a very good recovery, although slow, but his progress, considering the unusual severity of a case developing so early after injury, was quite remarkable.

#### RETROPERITONEAL MYXOLIPOFIBROMA

DR. FRANK S. MATHEWS showed a patient that had presented no symptoms except abdominal enlargement. A very large soft tumor could be felt in the upper abdomen descending almost to the pelvis. It was thought most likely a cyst of the pancreas. Operation showed that it was retroperitoneal, extending to the diaphragm on the left side and downward into the mesentery of the descending colon. The spleen was displaced forward and the tumor was very intimately related with the left kidney, behind which it lay, and which was displaced forward so as to be in contact with the abdominal wall. The tumor was oedematous and proved to be a myxolipofibroma with possibly some sarcomatous transformation.

## PNEUMOCOCCUS PERITONITIS

### CHONDROMA OF ANTERIOR SURFACE OF ILIUM

DOCTOR MATHEWS then presented a patient, thirty-eight years of age, who applied for enlistment but was rejected and sent to St. Luke's Hospital because of a tumor filling the left iliac fossa, extending two inches above and to the right of the umbilicus well over into the true pelvis, up into the loin and under Poupart's ligament. It cast no X-ray shadow, was a pure chondroma and weighed between three and four pounds. Displacement of the iliac vessels caused the left extremity to swell. The first impression was that the tumor was inoperable; the second, that under no circumstances could it be removed with its capsule because of the certainty of injuring vessels and ureter in the pelvic wall, as well as the sigmoid flexure whose mesentery it invaded. It was, however, attacked by an incision above Poupart's ligament which extended directly into the tumor, with finger and curette. The entire tumor was removed intracapsularly. The peritoneal cavity was invaded at some places. Patient made an uneventful recovery. The swelling of the thigh has disappeared.

## PNEUMOCOCCUS PERITONITIS

DR. PARKER SYMS read a paper with the above title.

DR. A. V. S. LAMBERT stated that at the Presbyterian Hospital there had been some cases of idiopathic peritonitis which on being studied bacteriologically proved to be of the pneumococcus variety. Last winter there was a particularly interesting group of cases: The father had pneumonia, was taken ill in his home in a tenement, taken from there to the Rockefeller Institute, where the pneumococcus Group I was isolated; two days later his daughter was taken ill in the same tenement, removed to the Rockefeller Institute, there diagnosed as appendicitis and sent to the Presbyterian Hospital, where she was operated on with a diffuse peritonitis from which was recovered the pneumococcus of Group I. Her blood was taken at the time of the operation, showing a bacteræmia, pneumococcus No. 1, and subsequently she developed a post-operative pneumonia of the same group. She was drained at the time of operation and suppurated rather profusely through the opening, and the nurse who took care of her developed a pneumococcic peritonitis, Group I, with a bacteræmia and a post-operative pneumonia. Both she and the child recovered of their peritonitis, both were treated with serum and both on the day prior to operation had a throat culture positive for pneumococcus No. 1. The nurse had the localized type of peritonitis, the child the diffuse type, which goes to prove that at least one group of pneumococcus will give both types of disease. Both developed a post-operative pneumonia, which is a very frequent, if not constant, sequel of pneumococcus bacteræmia in patients receiving ether as an anæsthetic.

DR. GEORGE WOOLSEY referred to a case presented by him before the Society some years previously and recalled one or two other cases which had led him to write a paper upon this subject. He considered that there

were many interesting problems connected with this condition. He understood that Doctor Syms advised no operation for the diffuse form of peritonitis, advocating, if possible, waiting for the encysted stage. He did not consider it always easy to make a pre-operative diagnosis of pneumococcus peritonitis, although there are several features that are suggestive. With regard to diarrhoea, this sometimes accompanies appendicitis in children; again, high temperature may be an accompaniment of appendicitis, especially in children. He thinks that the diagnosis is not made until operation in the majority of cases. He had a case in which a leucocytosis of over sixty thousand suggested the diagnosis of pneumococcus peritonitis. At operation there is the odorless fluid with the fibrin and the typical color to help in the diagnosis. Doctor Woolsey doubted whether the non-operative treatment would present a better mortality rate than the operative, as he believed many cases had been reported where operation had resulted favorably.

He could offer nothing toward the solution of the question as to why this condition should occur more frequently in girls than in boys, since the pelvic organs so far have not been found to be a site of infection. In secondary cases the swallowing instead of the expectoration of the discharges might partly account for the high incidence in children, but not for the higher incidence in girls.

DR. HOWARD LILIENTHAL stated that he had seen a number of these cases, had operated upon two, both female children, both of whom died; he had never seen a male child with this condition. Since these two fatal cases he had adopted the rule that whenever the pediatrician turned over to him a suspected case of pneumococcus peritonitis he advised against operation. He stated that he had operated upon one female adult in whom Friedlander's bacillus was isolated, a case of encysted peritonitis, the patient making a good recovery.

He asked whether pneumococcus peritonitis was the only form in which operation was not indicated, suggesting that acute gonococcus peritonitis be placed in the same category.

DR. A. C. WHIPPLE spoke of the bacteriology of the disease as found in the Presbyterian Hospital in the last two years, stating that this had been intensively studied in seven cases. Pneumococcus Group I was found in three and Pneumococcus Group IV in one. Two of the Group I cases recovered. In these cases, serum treatment was used. The other Group I died and the Group IV case died very promptly, having a diffuse form of peritonitis.

If the procedure is followed of injecting into a mouse some of the exudate from the peritoneum when the patient does not seem to have a diffuse peritonitis of intestinal origin, the diagnosis will be cleared up promptly, because the mouse will die within six hours of a pneumococcus bacteræmia. The isolation of pneumococcus can almost always be done within eight hours by this means, definitely proving to which group it belongs, and if to Group I the serum can be administered at an early stage.

He called attention to a point mentioned by Doctor Lambert, that if the sputum of the patient shows a Group I pneumococcus in the anti-operative examinations and if that patient should come down later with abdominal symptoms, the diagnosis would probably be more definite, because the presence of pneumococci in the sputum, especially the parasitic varieties I, II, III, is more apt to be found in the throat because of contact with other pneumonia patients. Laboratory methods, particularly with the mouse inoculation, make it possible to clear up the diagnosis in these cases much more rapidly and definitely than was formerly the case.

DR. NATHANIEL W. GREEN referred to a case of idiopathic peritonitis presented by him five years ago. It was a case of a little girl operated for appendicitis, but nothing was found to corroborate this diagnosis except the inflammation of the peritoneum. The exudate was cultured and proved to be streptococcus. Subsequent to operation the patient developed another collection of pus on the opposite side and microscopically and culturally this proved to be pneumococcus. He considered it probable, according to Rose-now's theory, this was the same infection in different stages.

DR. JOHN DOUGLAS called attention to the fact that in a certain number of cases of pneumonia in children the first symptoms are abdominal and he considered it questionable whether a number of these cases of pneumonia affecting the lung are not in the beginning a general bacteræmia in which there is a certain amount of irritation of the peritoneum. In the last two years he has seen two cases with a diagnosis of appendicitis where there were no physical signs of pneumonia in the lung, but where an X-ray picture showed a beginning focus at the root of the lung extending upward, physical signs developing twelve to twenty-four hours later. He referred also to one child in whom a diagnosis of appendicitis was on three distinct occasions made, but before operation was instituted he promptly in each instance developed a pneumonia.

DR. PARKER SYMS, in closing, stated that at Lebanon Hospital he found reports of eight cases of idiopathic peritonitis in which there had been a clinical or surgical diagnosis of pneumococcus peritonitis; three of these cases had not been examined bacteriologically. Of the five cases bacteriologically examined, three showed streptococcus and two showed pneumococcus. A point to be made is that an ordinary bacteriological examination is not enough to avoid mistake between streptococcus and pneumococcus. Unless the most elaborate tests are employed a definite decision cannot be reached.

As regards Doctor Lilienthal's question, the speaker stated that he had had no personal experience with idiopathic gonococcus peritonitis. Excepting this and peritonitis due to the streptococcus and pneumococcus, he believed all acute cases of peritonitis suitable for operation.

As to the difference in the types of the disease, namely, the encysted and the diffuse forms, he wished to state that probably none of the cases are encysted at first, but that some have a tendency to become encysted and that these

possibly represent a certain type of the disease; on the other hand, there are other cases that have no tendency to become encysted and which continue to be of the diffuse form. In cases of diffuse pneumococcus peritonitis he did not consider operation indicated; but he agreed with Doctor Woolsey that it was almost impossible to make a differential diagnosis unless confronted with a patient in an extremely depressed toxic condition, far beyond anything the abdominal symptoms would account for, where it may be seen that we are dealing with a systemic disease in which operation is contra-indicated.

He agreed with Doctor Douglas that some cases of pneumonia showed marked symptoms of peritoneal irritation. In fact, in pneumonia cases in which there is no peritonitis evident, nevertheless it may be possible to obtain plate cultures of pneumococci from the peritoneum.

## BOOK REVIEW

LES PLAIES DE GUERRE DU POUMON. Notes sur leur traitement chirurgical dans la zone des armées. By PIERRE DUVAL. Masson & Cie, Editeurs. Paris, 1917.

This little volume is well worth the careful attention of students of thoracic surgery. The author, speaking from a wide personal experience, reaches certain conclusions which from all viewpoints appear sound and reasonable. Duval's main contention is that the frightful mortality of war wounds of the lung, which he estimates all in all as nearly 50 per cent., can be greatly reduced by treating these wounds according to the old and well-tried surgical principles as applied to wounds of other parts of the body. Instead of the timid waiting for the condition to become worse, he believes that early and thorough operation should be the rule. The point is emphasized that these patients bear surgery well—on the whole, better than those wounded in the abdomen.

Omitting those who die immediately or in the first aid stations, this author, from a study of 3453 cases, not including his own, concludes that of the patients who are fortunate enough to reach some hospital behind the first aid station fully 20 per cent. die. He concludes that from 25 per cent. to 30 per cent. die in the *poste de secours*, where most of the fatalities are due to hemorrhage and mechanotraumatic asphyxia. None of these mortality figures take into account the deaths from the secondary suppuration—so apt to occur in a terrain where pathogenic flora abound like that of the Somme battles.

There is a tremendous difference in the mortality following artillery wounds as against rifle ball punctures—a difference amounting to the proportion of eight to one (Schmid). Indeed, modern bullet wounds of the lung are apt to be "benign" (!) unless a large vessel has been hit. In artillery wounds the presence of shell fragments, bits of clothing, and splinters of bone is prone to cause speedy and dangerous infection unless quickly removed. Bone fragments are particularly frequent in tangential wounds of the chest wall, but their presence should be suspected in every case complicated by fracture.

Not infrequently lesions of the opposite lung have been noted, the cause of which Duval ascribes to *contre coup*. Rupture of the visceral pleura of the other lung and even purulent pleurisy have been noted. Lefevre had a case in which after extracting a foreign body from the upper lobe the patient succumbed from gangrene and hemorrhage of the lower lobe of the same lung.

Chapter III deals with hemorrhage. As the title naively has it, "L'Hémorragie mortelle dans les plaies du poumon et son traitement chirurgical d'urgence." This slip is an indication of the extremely grave view which is taken of severe traumatic pulmonary hemorrhage. Imme-

diate operation is the only chance for saving life. Hæmothorax is usually inversely proportionate to the amount of external bleeding. And it must not be forgotten that wounds apparently not related to the chest may still cause thoracic bleeding. DePage saw a case in which the only external wound was in the arm. Many patients suffering from hemorrhage were apparently doing well at the *poste de secours* but quickly sank and died after transportation to the hospital. Duval believes, therefore, that in these cases operation to check bleeding should be performed near the place where the casualty occurred. Late hemorrhage may be accompanied by hæmoptysis but the latter phenomenon alone is rare. It sometimes occurs with pulmonary gangrene. True secondary hemorrhage as well as other dangerous complications may follow the retention of shell fragments in the lung. Obviously, external bleeding must be checked, but many good surgeons advise against early operations in the intrathoracic hemorrhages. Even so good a man as Hartmann fears "precipitate operation in the closed thorax cases." Duval, however, wisely advises early thoracotomy. It is quite as important to operate for hemorrhage here as it is to perform laparotomy for the dangerous intra-abdominal bleeding of ruptured ectopic gestation. Indeed, in the progressive hæmothorax we have the added danger of mechanical pressure.

In making the diagnosis the greatest care must be exercised in making the physical examinations, for these patients are apt to die very suddenly on slight exertion. Sitting erect for X-ray examination is out of the question. Porter and DePage have shown the diagnostic value of repeated observations of the blood-pressure. If the manometer shows a rapid fall, the need for operation is urgent. Duval believes that two-thirds of these desperate cases can be saved.

Shell wounds of the lung are prone to be followed by anaërobic infection of the effused blood, and the danger of lung infection is greatest when there is a small hæmothorax with the viscus adherent to the chest wall. Pulmonary abscess is to be expected around a foreign body or a spicule of bone. Lesions of one lung with suppression of function are frequently complicated by pneumonia of the opposite side and such opposite side infections are of grave import. Early extraction of the projectile tends to prevent this complication.

An interesting point brought out is the sensitiveness of the pleura to anaërobic infection and the comparative immunity of the lung itself to this same infection. He reasons, therefore, that the pulmonary wound should be closed promptly, thus attempting to seal off the lung-dwelling anaërobes from the pleural sac. The infection beginning in the fibrin and clots of the hæmothorax rapidly spread to the incoagulable sanguinolent fluid within the chest. Bacteriological studies of the exudate are valuable in determining the necessity for early operation. As a field laboratory method it has been found that milk mixed with the suspected fluid and then heated until the bubbles are driven off will act as an anaërobic medium.



Repeated puncture may be necessary to keep track of advancing infection.

Duval claims priority (December, 1916) in suggesting the immediate operative treatment of pulmonary wounds and applying the same surgical principles as obtain in wounds of other parts of the body. He calls attention to the grave dangers of pleural infections, drawing a parallel with peritonitis from injuries of the abdominal viscera.

The proper procedure consists in thorough exploration and inspection of the wounded lung with treatment according to the character of the injury. In "blind" wounds of the lung with no point of exit, removal of the fragment is practised with the aid of Röntgenoscopy. Pulmonary perforations are cleaned out by reaming with gauze strips and the tract closed by suture. Surface wounds are mechanically cleansed and the edges approximated with mattress sutures. Systematic exploration of the lungs is practised by withdrawing lobe after lobe from a wound made by widely resecting a rib and using a rib-spreading retractor. Both inspection and palpation are of value. Experiments in blood-pressure appear to demonstrate that in these war wounds of the lung shock is less pronounced than in wounds of the peritoneum. As in all branches of our art, the clinical judgment of the surgeon is all-important. Whenever possible, local anæsthesia should be employed. A widely opened thorax must be closed as soon as feasible, but in any event projectiles must be removed. A good, firm dressing with pressure will relieve the distress of "open thorax" so that the patient can be transported.

Duval objects to the use of differential chambers in these war wounds, because the lungs being constantly distended, exploration is greatly limited. Drawing the collapsed lung out of a generous thoracotomy permits of examination, lobe by lobe, just as abdominal viscera are drawn up to the wound and examiner. With the atelectatic lung this is simple—with distended lung impossible. Respiration and pulse are not as a rule seriously disturbed during this procedure, and blood-pressure has been shown to be less influenced in these thoracic operations than in laparotomies.

Spinal anæsthesia cannot be depended upon, and any inhalation anæsthesia Duval considers a factor which greatly increases the risk of operation. He regards immediate drainage of the pleura as unnecessary. Hæmostasis should be carried out by the usual method but packing should be a last resort. Pleural closure should be complete, and the retained air removed later by aspiration. This is considered preferable to blowing up the lungs by positive pressure at the close of the operation. Drainage had better be secondary, *i.e.*, instituted hours or days after the operation. During convalescence morphine is absolutely necessary. The patients, preferably reclining, should be segregated in a warm ward near the operation room.

There is an appendix which consists of case histories, with records of operations and postmortems as they illustrate the points made by the author. Also a brief study of certain phases of the bacteriology.

HOWARD LILIENTHAL.

## CORRESPONDENCE

### PAROVARIAN CYST IN A YOUNG GIRL

TO THE EDITOR OF THE ANNALS OF SURGERY.

DEAR SIR:

Most references to parovarian cysts infer that they do not occur, or at least are not sufficiently large to be demonstrated or cause trouble before the age of sixteen, or especially before the menstrual function has been fully established. Like all pathological conditions, however, variations present themselves, and it is for this reason that I am reporting this more or less interesting case of a parovarian cyst in a girl just past her twelfth birthday.

The patient was a well-developed girl just thirteen years of age, who had always enjoyed perfectly good health, with history negative in every respect. Her menstrual periods were established nine months before, were regular and without any subjective symptoms.

About six months before she had an acute attack of pain in the abdomen, which lasted for several days and was followed by complete recovery, and she remained well until the present time, when she had a similar attack and was referred to me for surgical interference.

The general appearance of the abdomen was that of about a six months pregnancy, the tumor being quite movable with the attachment at the lower portion. The right side of the abdomen was very sensitive to pressure, especially in the region of the appendix. The tumor itself produced no marked symptoms on pressure.

Urine analysis was negative, heart normal, temperature 100°, with some variation each way, and pulse about 95, also with some variation. Blood count: Red cells, 5,800,000; white cells, 11,600; hæmoglobin, 95. Differential count, mononuclear leucocytes, .26; polymorphonuclear leucocytes, .74. Color index, 95.

Abdominal incision revealed an acute non-suppurative appendicitis and a parovarian cyst.

The cyst when delivered presented the usual characteristic appearance, viz.: the vascular wall, the long drawn out Fallopian tube stretched over its surface with the ovary crowded to one side, and, contrary to the usual condition of being fixed to the broad ligament, it had a pedicle attached to the parovarium long enough to be twisted on itself twice. The cyst was unilocular, it contained just a little over twenty-four hundred cubic centimetres of perfectly clear fluid of a slightly syrupy consistency and with a specific gravity of 1003 and contained a trace of albumin. No difficulty was encountered in its removal, the appendectomy followed, and the patient made a very good recovery and at this time, three months later, she is enjoying perfectly good health.

CHARLES E. SLAGLE, M.D.,  
Alliance, Nebraska.

December 21, 1917.

## THE HYPOCHONDRIAC TYMPANY SYMPTOM OF PERFORATED GASTRODUODENAL ULCERS

EDITOR OF THE ANNALS OF SURGERY:

I should like to call attention to the occurrence of a symptom in perforated gastric or duodenal ulcers which I believe is of aid in the differential diagnosis.

I refer specifically to a small area of localized tympany over the liver. It is found in the parasternal line between the inferior and superior borders of the liver. It is rarely larger in extent than the palm of one's hand. It is readily elicited by simple percussion.

Though it is generally admitted that obliteration of the liver dulness is an important symptom in this diagnosis, one must admit that it is infrequently found. On the other hand, I have found this area of localized tympany in a fair percentage of cases. I have operated on ten cases of acute perforations of gastric and duodenal ulcers. As the records are not immediately available, actual statistics cannot be given. It is my impression, however, that this symptom may be found in at least 50 per cent. of the cases. I am at a loss to explain its occurrence. As a pool of gastric or intestinal contents is often found in the region of the perforated ulcer, it seems possible that the escaped free air is driven upward to the dome of the diaphragm where its passage is then prevented by the falciform ligament of the liver. This, however, is purely speculation.

ANTHONY H. HARRIGAN,  
New York.

January 3, 1918.

## SUTURE OF WOUND IN FEMORAL ARTERY

EDITOR OF THE ANNALS OF SURGERY:

A young man, eighteen years of age, was brought to the Birmingham Infirmary by Drs. Finley and Yielding, January 7, 1917, with the history of an accidental stab of the lower inner side of the thigh just below Hunter's canal. There had been some bleeding and some clots had been removed by a slight enlargement of the skin wound.

When I saw him the circulation in the limb was good and the leg was only slightly enlarged. We decided that there was probably an injury of some muscular branch with bleeding into the tissues, and put him to bed with his foot elevated. He improved and was asking to be sent home, when on January 24 he began to suffer violently and the leg became considerably swollen at this point. The following day, with a tourniquet around the upper part of the thigh, a long incision was made over the course of the Sartorius muscle, which was dissected up; the heavy fascia beneath was very tense, and, on being incised, a false aneurism three or four inches long beneath it was found, together with a wound in the femoral artery a third of an inch long. The wound in the artery was closed with six interrupted chromic catgut No. 1.

## CORRESPONDENCE

When the tourniquet was removed no bleeding occurred. The Sartorius muscle was then sutured down over the arterial suture line and the cavity obliterated with catgut. A tube drain was placed in the upper end of this cavity and the rest of the wound closed. The foot of the bed was elevated and hot water bottles applied to the foot and leg.

The circulation was normal from the time of operation. He was kept in bed two weeks, and then was allowed to go home on crutches, which he soon discarded. At the end of five months Dr. Yielding reports him perfectly well and doing hard work on his farm.

GASTON TORRANCE, M.D.,  
Birmingham, Ala.

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## THE EFFECT OF TRAUMA UPON THE LARYNGEAL NERVES

AN EXPERIMENTAL STUDY

By E. S. JUDD, M.D., G. B. NEW, M.D., AND F. C. MANN, M.D.

OF ROCHESTER, MINNESOTA

FROM time to time, a complete or partial paralysis of the vocal cords is seen following thyroidectomy. The purpose of this research was to determine if possible the cause of such paralysis. It was believed that the best method by which to attempt to solve the problem would be to study the effect of traumatic procedures on the recurrent laryngeal nerves in dogs.

The method of experimentation consisted in traumatizing the laryngeal nerves in a manner similar to that which could occur in an operation and subsequently to study the function of the vocal cords. The results of these traumatic procedures can only be applied specifically to the recurrent laryngeal nerves, for the results may not be the same for other nerves of a different size or in a different location.

All operations were done under ether anæsthesia, employing sterile technic. The various operations differed only in regard to the traumatic procedure used. On the day following the operation the function of the cords was observed. These observations were subsequently made as frequently and over as long a time as seemed necessary in each individual experiment.

The function of the vocal cords was observed by direct laryngoscopy without an anæsthetic. It is impossible to get the animal voluntarily to approximate the cords as may be done in the human being, but their action was readily observed when the dog attempted to make a noise. In observing complete bilateral cord paralysis in the dog, inspiration frequently causes approximation, but this is easily differentiated from a functioning cord. To make the observation free from all personal bias the observer made notes of the result of his examination without knowledge of the operation performed or the results of his previous observations.

Injury to the recurrent laryngeal nerves produces some general effects which should be noted. The severity of these effects depends on whether one or both nerves are injured and also the anatomic site of injury. Owing to the fact that the laryngeal nerve gives off branches to the trachea and œsophagus, the results of injury are greater when these branches are also involved, *i.e.*, when the point of injury is at a considerable distance from the larynx. Usually when only one nerve is involved, the general results are not marked.

Complete destruction of the function of both recurrent laryngeal nerves

at a point below the lower poles of the thyroid of the dog, results in some inability of the animal to swallow properly, a total loss of voice, and sometimes dyspnœa. In most cases very little effect on the ability of the animal to swallow was noted. The voice was always lost, although in many instances the animal was able to produce various sounds. Many of the animals suffered from dyspnœa continuously, while most of the others could be made dyspnœic from exertion. This result which differs from that observed in the human being is probably due to the fact that the paralyzed cords tend to fall inward on inspiration in the dog and to form pockets laterally. This acts like a valve and in extreme cases the air will be completely shut off. The faster and harder the animal attempts to breathe the greater the difficulty of passing air into the trachea. Many of the dogs could not exert themselves in the least without inducing the greatest dyspnœa and in some cases cyanosis.

The effect of pinching was studied. The nerves were picked up at various points of their course and pinched once with a hæmostat in a manner similar to that necessary to stop hemorrhage from a small vessel. In every instance in which a nerve was pinched the corresponding vocal cord was paralyzed. In all animals that lived long enough, the function of the cord was later fully restored. The time necessary for the restoration of the function depended on the anatomical point at which the nerve was pinched. When the trauma was applied to the nerve at its entrance into the larynx the function of the cord was found to be restored as early as thirty days after operation; when the nerve was pinched below the lower pole of the thyroid, sixty days elapsed before the cord functionated normally.

Three kinds of suture material were used to study the effect of ligation, linen, chromic catgut Nos. 1 and 2, and plain catgut No. 1. The nerves were ligated with about the same tension used in ligating small vessels. Every cord, where the nerve was ligated, was paralyzed, and in no instance was recovery noted, although in the majority of experiments the observations were carried on long enough for regeneration to have occurred. It seems that all suture material produces enough permanent obstruction to prevent regeneration in a nerve as small as the laryngeal. At autopsy this obstruction, due to the suture material or the reaction to it, could be definitely located grossly.

Several of the nerves were sectioned and allowed to drop back into their original position. The cords paralyzed by the procedure never recovered. Some of these nerves were examined at autopsy and the ends were found to be as far apart as .5 cm.

Three methods were employed to stretch the nerves. In some instances a hæmostat was placed under both nerves and traction was applied for a definite length of time, which varied from ten to thirty minutes. In other experiments small retractors were placed on each side below the lower pole of the thyroid and traction outward was made for a definite length of time. In the latter case the nerve itself was not disturbed. Finally the nerve was dissected free for a considerable length and after splitting one of the muscles of the neck the nerve was sutured around it in such a manner as to place

## EFFECT OF TRAUMA UPON LARYNGEAL NERVES

it on tension. In all instances the stretching was more severe than would occur during operation and by the first two methods only produced paralysis in one case. It is possible that this was due to trauma at the time of exposure and not to the stretching. When the nerves were stretched over muscles, paralysis occurred more frequently, but this also was due probably to the operative trauma and not to the stretching.

In several animals the nerves were dissected free for several centimetres (explored). In some cases paralysis followed, probably due to the trauma incident to freeing the nerves.

In four experiments the superior laryngeal nerves were sectioned. Subsequent examination of the vocal cords did not reveal any impairment of function.

The table gives the data in an abbreviated form. Many of the experiments were ended prematurely because of an epidemic of distemper.

### CONCLUSIONS

1. Section of the recurrent laryngeal nerve produces complete paralysis of the vocal cord of the corresponding side which in all probability will be permanent.

2. Ligation of the recurrent laryngeal nerve with linen, chromic catgut or plain catgut produces complete and probably permanent paralysis of the vocal cord of the corresponding side.

3. Stretching the recurrent laryngeal nerves acutely in a manner similar but of longer duration and intensity than occurs in operation does not impair the function of the vocal cord.

4. Stretching the recurrent laryngeal nerves for a long period, as over muscles, impairs the function of the vocal cords, but the impairment is probably due to the operative trauma and not to the stretching.

5. Pinching the recurrent laryngeal nerves with a hæmostat in a manner similar to that which may occur in an operation, produces temporary paralysis of the vocal cords. Restoration of function always occurs, the length of time necessary for restoration depending on the anatomical point at which the nerve was crushed. The time found necessary for complete regeneration of the nerve when injured in the areas usually traumatized by operation varies between thirty and sixty days.

6. Exploration of the recurrent laryngeal nerves produces an effect on the vocal cords depending on the amount of trauma to which the nerves are subjected. Careful dissection will probably not produce any effect; the paralyzes noted were probably due to pinching and other traumatic procedures.

### SUMMARY

*Pinching; number of nerves pinched, 24.* All cords were paralyzed. The function of all the cords in which the nerves were pinched at the lower pole of the thyroid was restored within sixty days. When the nerves were pinched close to the larynx the function of the cords was found to be restored within thirty days.

*Ligation with chromic catgut; number of nerves ligated, 9.* All cords were paralyzed. The function was never restored. Longest time observed after operation was 371 days.

*Ligation with plain catgut; number of nerves ligated, 6.* All cords were paralyzed. The function was never restored. Longest time observed after operation was 320 days.

*Ligation with linen; number of nerves ligated, 4.* All cords were paralyzed. The function was never restored. Longest time observed after operation was 372 days.

*Section; number of nerves sectioned, 8.* All cords were paralyzed. The function was never restored. Longest time observed after operation was 372 days.

*Resection; number of nerves resected, 1.* The cord was paralyzed. The function was not restored after 160 days.

*Stretched (acute); number of nerves stretched, 9.* In one case the cord was paralyzed. No paralysis occurred in eight cases.

*Stretched over muscles; number of nerves used, 4.* Three cords were paralyzed. The function of two was restored within forty-eight days; the third was still paralyzed on twenty-second day.

*Explored; number of nerves explored, 8.* Three were not paralyzed; three were paralyzed and remained so at end of fifteen, eighteen and nineteen days, respectively. The function of one was restored in fourteen days; the function of another was partially restored after twenty-three days.

TABLE SHOWING THE RESULTS OF EXPERIMENTS ON THE EFFECT OF TRAUMATIC PROCEDURES TO THE RECURRENT LARYNGEAL NERVES

Experiment	Operation (pinched)	Results
494-16	Pinched right nerve	Complete paralysis. No restoration of function at the end of 17 days.
500-16	Pinched both nerves	Complete paralysis. Function of left cord restored within 40 days; function of right cord normal within 63 days.
511-16	Pinched right nerve	Complete paralysis. No restoration of function on fourth day.
512-16	Pinched right nerve	Complete paralysis. No restoration of function within 15 days.
598-16	Pinched both nerves	Complete paralysis. No restoration of function within 10 days.
599-16	Pinched both nerves	Complete paralysis. Function fully restored 50 days.
600-16	Pinched both nerves	Complete paralysis. Function fully restored 50 days after operation.
611-16	Pinched left nerve	Complete paralysis. Function fully restored 48 days after operation.
651-16	Pinched left nerve at level of lower pole of thyroid. Pinched right nerve 5 cm. below point at which left was pinched	Complete paralysis. Function of left cord restored 49 days after operation; right was still slightly paralyzed. It completely regenerated later.
654-16	Pinched right nerve	Complete paralysis. No restoration of function at end of twenty-second day.
663-16	Pinched right nerve	Complete paralysis. No restoration of function within 18 days.
664-16	Pinched both nerves near lower pole of thyroid	Complete paralysis. Function restored within 45 days.
738-16	Pinched right nerve below level of lower pole of thyroid; pinched left nerve just below point of entrance into larynx	Complete paralysis. Function of right cord not restored within 26 days; function of left about half restored.
739-16	Pinched both nerves at entrance to larynx	Complete paralysis. Twenty-sixth day right cord paralyzed 2; left cord paralyzed 1; thirtieth day right cord paralyzed 1; left cord normal; thirty-third day right cord normal.
740-16	Pinched right nerve	Complete paralysis. No restoration of function within 24 days.
741-16	Pinched both nerves	Complete paralysis. No restoration of function within 25 days.



# EFFECT OF TRAUMA UPON LARYNGEAL NERVES

TABLES SHOWING THE RESULTS OF EXPERIMENTS ON THE EFFECT OF TRAUMATIC PROCEDURES TO THE RECURRENT LARYNGEAL NERVES—*Continued.*

Experiment	Operation (ligated with chromic catgut)	Results
503-16	Ligated right nerve	Complete paralysis. No restoration of function within 75 days.
504-16	Ligated both nerves	Complete paralysis. No restoration of function within 46 days.
505-16	Ligated right nerve	Complete paralysis. No restoration of function within 318 days.
506-16	Ligated right nerve	Complete paralysis. No restoration of function within 371 days.
611-16	Ligated right nerve	Complete paralysis. No restoration of function within 22 days.
613-16	Ligated right nerve	Complete paralysis. No restoration of function within 110 days.
665-16	Ligated right nerve	Complete paralysis. No restoration of function within 18 days.

Experiment	Operation (ligated with plain catgut)	Results
601-16	Ligated both nerves	Complete paralysis. Left cord removed ninth day for marked dyspnoea. No regeneration of right nerve within 320 days.
742-16	Ligated both nerves	Complete paralysis. No restoration of function within 22 days.
12-17	Ligated both nerves	Complete paralysis. No restoration of function within 228 days.

Experiment	Operation (ligated with linen)	Results
499-16	Ligated both nerves	Complete paralysis. No restoration of function within 16 days.
502-16	Ligated right nerve	Complete paralysis. No restoration of function within 372 days.
503-16	Ligated left nerve	Complete paralysis. No restoration of function within 75 days.
665-16	Ligated left nerve	Complete paralysis. No restoration of function within 18 days.

Experiment	Operation (sectioned)	Results
493-16	Sectioned right nerve	Complete paralysis. No restoration of function within 237 days.
509-16	Sectioned right nerve	Complete paralysis. No restoration of function within 262 days.
510-16	Sectioned left nerve	Complete paralysis. No restoration of function within 15 days.
511-16	Sectioned left nerve	Complete paralysis. No restoration of function within 11 days.
512-16	Sectioned left nerve	Complete paralysis. No restoration of function within 22 days.
655-16	Sectioned left nerve	Complete paralysis. No restoration of function within 90 days.
10-17	Sectioned right nerve	Complete paralysis. No restoration of function within 7 days.

JUDD, NEW AND MANN

TABLES SHOWING THE RESULTS OF EXPERIMENTS ON THE EFFECT OF TRAUMATIC  
PROCEDURES TO THE RECURRENT LARYNGEAL NERVES—*Continued.*

Experiment	Operation (resected)	Results
493-16	Resected 5 cm. of left nerve	Complete paralysis. No restoration of function within 237 days.

Experiment	Operation (stretched for period of operation)	Results
508-16	Stretched both nerves for short interval, probably two minutes	Cords normal.
509-16	Stretched left nerve	Cord normal.
656-16	Stretched both nerves for ten minutes	Cords normal.
666-16	Stretched both nerves for twenty minutes	Left cord paralyzed 3. Right cord normal. Both cords normal within 18 days.
13-17	Stretched both nerves for twenty minutes	Cords normal.

Experiment	Operation (stretched by suturing around muscles)	Results
653-16	Sutured both nerves around muscles	Complete paralysis. Function restored within 218 days.
651-16	Sutured left nerve around muscles	Complete paralysis. No restoration of function within 22 days.
655-16	Sutured right nerve around muscles	Cord normal.

Experiment	Operation (explored)	Results
502-16	Explored left nerve	Cord normal.
510-16	Explored right nerve	Complete paralysis. Did not recover within 15 days.
665-16	Explored left nerve	Complete paralysis. Did not recover within 18 days.
9-17	Explored both nerves	Complete paralysis. After 6 days left cord paralyzed 2; right cord complete; after 10 days left 1, right 3; after 14 days left O. K.; right 3; after 23 days right 2. Both cords normal on eighty-ninth day.
10-17	Explored left nerve	Cord normal.
11-17	Explored both nerves	Left cord normal; right paralyzed; bloody effusion from wound; much bleeding on right side at operation. Right cord still paralyzed after 20 days.

## PNEUMOCOCCUS PERITONITIS\*

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BECAUSE I believe diagnosis in connection with this disease to be of great importance as bearing on its proper treatment, and because there is such a paucity of American literature concerning it, I have been prompted to bring this subject before the New York Surgical Society.

Idiopathic pneumococcus peritonitis does exist, and in its diffuse form or stage operation is extremely dangerous, usually resulting in death. I believe operation should be avoided in this phase of the disease. Were this not a fact we could hold the dictum that for acute peritonitis in child or adult immediate operation is the proper form of treatment. But this exception exists and it makes it doubly important that we should have the salient features of this disease ever in mind when we encounter a case of acute peritonitis.

A search through the literature reveals many excellent articles from England, France, Italy, and Germany, but very little is to be found in American journals. During the last seven years no article has appeared in *Surgery, Gynecology and Obstetrics*, and during the last ten years but one article has appeared in the *ANNALS OF SURGERY* and but one article in *The American Journal of Medical Sciences*. I believe a more general recognition of this disease is needed in order that we may clear up certain points which still require elucidation. The greatest practical good can come from a systematic study of all of our acute peritonitis cases with the picture of this disease ever before us.

We have gradually come to realize that pneumococcus peritonitis is a clinical entity. Prior to 1889, when appendicitis was first operated upon, we knew comparatively little about peritonitis. What we thought we knew was based upon clinical experience and upon observation made at necropsy. During that period of comparative ignorance much was said about idiopathic peritonitis. After 1890 laparotomy for acute appendicitis became one of our most common procedures. Then it was found that peritonitis was almost invariably the result of infection from a hollow viscus—appendix, intestine, gall-bladder, etc., and we came to feel that there was no such thing as idiopathic peritonitis, except the tubercular form; but the experience of opening the abdomen and finding a diffuse or encysted peritonitis, with the appendix, gall-bladder, and uterine appendages normal, and with no evidence to be found of an original focus of infection, demonstrated the fact that peritonitis may begin as a primary or idiopathic lesion. A further study has led to the discovery that acute idiopathic peritonitis may be caused by the gonococcus, the streptococcus, and the pneumococcus, and

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that chronic idiopathic peritonitis may be caused by the tubercle bacillus. N.B. The colon bacillus, though always present in the intestine, does not cause peritonitis, except by perforation or extension.

For a historic sketch or review of the study of this disease I take the liberty of transcribing that which is found in the excellent article by Annand and Bowen.<sup>1</sup>

"In 1885 de Bozzola<sup>2</sup> described a case of infection of several serous cavities with numerous capsulated cocci in the exudate following on a nephritis. The case, however, was not fully worked out. In the following year Cornil<sup>3</sup> performed a necropsy on a case of pneumococcus peritonitis following pneumonia and associated with double empyema and pyopericarditis. During the next year or two isolated cases were here and there reported and in 1890 Nelaton<sup>4</sup> undertook the first operation for the relief of the condition, in a woman aged thirty-two, but without success. Galliard<sup>5</sup> and Sevestre<sup>6</sup> also operated during the same year on cases of pneumococcus peritonitis; Sevestre's case being a child with apparently primary involvement of the peritoneum. This case recovered and remained well. On the continent numerous examples of the disease now began to be recorded, for the most part from France. In 1903 Von Brunn<sup>7</sup> was able, in an excellent paper on the subject, to collect 57 cases of the disease in children and a further 15 adult cases. In the same year Jensen,<sup>8</sup> of Copenhagen, published a lengthy article on the disease, and in this he discussed the affection very fully. These two papers are up to now the most important contributions to the subject. Since the date of Von Brunn's paper, Mathews<sup>9</sup> and Bryant<sup>10</sup> have brought forward fresh cases and have written on pneumococcus peritonitis; other papers have been contributed by Quervain<sup>11</sup> and Ghon,<sup>12</sup> while cases have been reported by Panzacchi,<sup>13</sup> Brun,<sup>14</sup> Powell,<sup>15</sup> Taylor,<sup>16</sup> Waldo,<sup>17</sup> Webber,<sup>18</sup> Fisher,<sup>19</sup> Dudgeon and Sargent,<sup>20</sup> Davies and Langdon Brown,<sup>21</sup> and Duckworth and Marsh.<sup>22</sup> As a result of a search of the literature we have been able to find record of 91 cases of pneumococcus peritonitis in children below the age of fifteen years, including the cases reported above."

In 1904 Frank Mathews<sup>9</sup> published a paper in the *ANNALS OF SURGERY*. He reported 5 fatal cases. He reviewed and analyzed the work of Jensen<sup>8</sup> and that of Max Von Brunn.<sup>7</sup>

In 1908 H. D. Rollerston<sup>23</sup> published an article on the subject in the *Clinical Journal of London*, and in 1911 George Woolsey<sup>24</sup> published a paper in *The American Journal of Medical Sciences*. In 1912 there appeared a paper by Hector Cameron<sup>25</sup> in *The British Journal of Children's Diseases*. One of the most recent articles on the subject is by L. M. Kahn, published in 1914.<sup>26</sup>

Among the most notable contributions to this subject may be cited those of Jensen,<sup>8</sup> Von Brunn,<sup>7</sup> Annand and Bowen,<sup>1</sup> Brun,<sup>14</sup> of Paris, and Michaut.<sup>27</sup> Michaut's thesis, so far as I know, is the most comprehensive brochure on the subject. In it can be found the sum of our present-day knowledge. I believe that very little has been added to our fund of information on this subject since Michaut's article was published in 1901.

Perhaps the best way to systematize our study of this subject will be to set down succinctly the facts which we have learned and which we recognize on the one hand, and then to set forth certain important features of the disease which have not yet been made clear, and whose elucidation may give

us a much more perfect conception of the subject, and also may enable us to treat this disease on a more definite and scientific basis.

From the recorded study of this subject, especially from the many case reports, we have learned certain facts as follows:

Idiopathic peritonitis caused by the pneumococcus is a pathological entity.

It is a rare disease. In 104 pneumococcus infections in adults that were studied by Netter,<sup>28</sup> he found no case of peritonitis. In 47 such infections in children, he found 1 case. In 140 cases of peritonitis which were bacteriologically examined by Netter,<sup>28</sup> he found pneumococcus twice.

It is a disease particularly affecting children. Up to the fifteenth year of age it is three times as prevalent as after that period.

It is much more frequent among girls than among boys in the proportion of three to one.

It may occur (1) as the only local manifestation; (2) as a sequel to some previous site of pneumococcus infection, *i.e.*, lung, pleura, pericardium, ear, etc., or (3) as a part of a general septicæmia in which other organs are simultaneously involved.

It is found in two varieties: (1) As a diffuse general peritonitis and (2) as an encysted or localized process. Some claim that these two conditions represent stages of the disease, that there is always a diffuse peritonitis at first which later becomes localized by intestinal adhesions. Others (Michaut<sup>27</sup>) claim that there are two distinct varieties of the disease.

The disease has been described as occurring in three stages, some say four.

The first stage is that of toxæmia, the child being overwhelmed by the poison. There is great depression and the patient is much more ill than the abdominal symptoms would indicate.

The second stage is characterized by abdominal symptoms; the signs of an advancing peritonitis.

The third stage is characterized by a continuance of the signs of peritonitis with effusion. During this period there is often an abatement of the active signs of toxæmia. The temperature may fall and the patient may seem decidedly less ill. If the pus has become encysted or localized there will be the signs of intra-abdominal abscess or abscesses. The abdomen becomes distended; this particularly relates to the lower part of the abdomen, for the disease is usually subumbilical. When loculation has taken place there is usually an irregular swelling of the abdomen, one side being affected more than the other. One characteristic of the disease in its late stages is the protrusion of the umbilicus and its final perforation. There have been many reports of discharge of pus through the umbilicus and this seems to be a condition almost peculiar to this disease. The discharge will be of the characteristic greenish-yellow, serofibrinous, odorless pus. N.B. If perforation at the umbilicus takes place in tubercular peritonitis there is very apt to be a fecal fistula.

The disease presents a clinical picture that is characteristic and which should lead to diagnosis in most primary cases. Its characteristic signs are sudden onset, extreme toxæmia, vomiting and diarrhœa, very high temperature, and very high leucocytosis with a high polymorphonuclear count. There is a notable absence of local pain, local tenderness, and local rigidity as compared with appendicitis or perforation peritonitis. Some have described the abdomen as having a "doughy" feel. Added to all this is the pneumonia aspect—cyanosis, slight dyspnœa, great depression, etc.

If the abdomen is opened there will be found a diffuse or a localized peritonitis or one that is becoming localized. As a rule no one organ will indicate a starting point (as an inflamed appendix, gall-bladder, etc.). The appearance of the exudate is characteristic and almost pathognomonic. It is a seropurulent fluid, perfectly odorless, of a yellowish-green color and containing great masses of fibrin. This fibrin is found floating in the exudate and also attached to the peritoneal surfaces.

Opinions differ as to whether there are two distinct varieties of pneumococcus peritonitis. Some claim that the diffuse peritonitis is a distinct type having a tendency to remain diffuse and to produce extreme toxæmia, and that the encysted is another type having a tendency to become localized early and to produce a lesser degree of toxæmia. (Of course, even the encysted cases are not encysted from the very beginning, it is the tendency to early localization that represents the difference.) Others claim that diffuse peritonitis without adhesions represents the first stage, and that adhesions with the formation of localized accumulations represent a later stage.

F. Brun,<sup>14</sup> who was an early writer on the subject, at first reported some cases of encysted pneumococcus peritonitis in which he found a very favorable outcome. In a later report he again cited some cases of the encysted form and published his conclusion that this was a rare form of peritonitis in which the prognosis was very good. He stated that it was one of the least fatal forms of peritonitis found among children. But later he encountered a group of cases of the diffuse variety which prompted him to make a subsequent report, for these diffuse cases proved extremely fatal. He concluded therefore that this second was a distinct variety having a much higher mortality than the encysted type.

Later his associate, Charles Michaut,<sup>27</sup> reported these cases of Brun's with some cases of his own and analyzed a collection of cases reported by others. Michaut<sup>27</sup> very clearly states the view that the two forms are two distinct varieties, and that each is caused by a strain of pneumococcus different from the other; the first being caused by a pneumococcus of comparatively little virulence, the second being caused by a pneumococcus of extreme virulence. This is one of the points yet to be cleared up and it can only be done by making a very careful study of our cases and a very careful and intelligent study of the bacteriology of each case until we have a sufficient number on which to base conclusions.

Von Brunn<sup>7</sup> speaks of the disease as having a favorable prognosis in

which spontaneous recovery may take place and in which recovery is the rule in cases operated. It is evident that his observations and impressions must have been gained from an experience with cases of the encysted form of peritonitis. Mathews<sup>9</sup> clearly pointed this out.

Hector Cameron<sup>25</sup> states his position very clearly when discussing the question of treatment. He regards the diffuse form of the peritonitis as belonging to the early stage and not as representing a distinct type of the disease.

Whether diffuse pneumococcus peritonitis is an early stage or a special form of the disease, the fact remains that it represents the period or condition of the utmost gravity. Annand and Bowen,<sup>1</sup> analyzing 91 cases that had been bacteriologically studied and satisfactorily reported, found in the diffuse form a mortality of 86 per cent. In the same series of cases in the encysted form there was a mortality of but 14 per cent.

In the same article Annand and Bowen<sup>1</sup> describe 16 cases which had occurred in the East London Hospital for Children. All 16 of these cases were of the diffuse variety. Death resulted in all 16, showing a mortality of 100 per cent.

Brun,<sup>14</sup> as quoted above, found the diffuse to have a much higher mortality than the encysted form.

Michaut's<sup>27</sup> investigation fully supports this fact. He believes the two conditions represent two varieties of the disease, each variety caused by a pneumococcus having a special degree of virulence. If the diffuse variety is caused by a bacterium of great virulence, the toxæmia will be great and the gravity of the disease will be in proportion to the virulence of the pneumococcus. The mortality will be high in proportion to the strain of pneumococcus involved. Does not this correspond with our modern investigation of the pneumococcus?

Cameron<sup>25</sup> regards the diffuse form as representing the period of maximum danger. He strongly advises against operation during this state. He gives several reasons to show that operation, in the diffuse form, is contra-indicated. The most cogent of all is to be found in the fact that operation shows so high a mortality—from 86 to 100 per cent.

L. M. Kahn<sup>26</sup> expressed essentially the same view as Cameron.<sup>25</sup> He regards the diffuse form as a stage, not a type of the disease. He recognizes its extreme gravity. He advises against operation in the diffuse "stage," and he very properly lays stress on the necessity for diagnosis.

In fact, all writers who have gone into this phase of the subject are essentially agreed.

*Diagnosis.*—All must recognize the importance of correct diagnosis of this condition. When we encounter a case of acute peritonitis, one of the first essentials is that we decide whether that case is or is not one of pneumococcus peritonitis, and if it is pneumococcus peritonitis whether it is diffuse or encysted. Because diffuse pneumococcus peritonitis should *not* be operated upon; encysted pneumococcus peritonitis *should* be operated

upon. All other forms of acute peritonitis, diffuse or encysted, should be operated upon, and the earlier the better.

The picture of primary pneumococcus peritonitis is so characteristic that diagnosis should be possible in typical cases. The salient points are: the sudden onset, the evidence of extreme toxæmia, great depression, etc. There is often a chill, there is always extremely high temperature, the blood count is very high. Diarrhœa is a conspicuous symptom; peritonitis with diarrhœa should always make one suspicious of pneumococcus. As compared with perforation-peritonitis there is lack of localizing symptoms; there is a lack of local pain, of local tenderness, of local rigidity. The abdomen is described as presenting a "doughy" feel. (Salzer.<sup>29</sup>) There may be the "pneumonia aspect"—cyanosis, dyspnœa, great depression, etc. The fact that the patient is far more ill than the abdominal condition would account for, is significant. As bacteræmia is generally, if not always, present, examination of the blood should be of great aid to diagnosis. In cases where a previous site of infection exists and where the peritonitis comes on as a secondary or late manifestation, the diagnosis will naturally be greatly obscured by the previous condition. Undoubtedly failure to diagnosticate peritonitis in such cases has been of frequent occurrence. When the peritonitis is established and when the effusion is formed there will be the signs of either free fluid in the abdomen or of loculated accumulations. In other words, there will be distention of the abdomen, either uniform or one-sided. This distention nearly always begins in the lower part of the abdomen; pneumococcus peritonitis usually begins as a subumbilical one. Protrusion or perforation at the umbilicus is a late sign and is very characteristic of this disease.

When the abdomen is opened there will be found the evidences of peritonitis described in a previous paragraph. As a rule, no local point of origin, as inflamed appendix, etc., will be found. Most diagnostic of all, however, will be the appearance and character of the exudate—an odorless, seropurulent fluid of a yellowish-green color, containing great masses of fibrin.

Clinically it is very difficult to distinguish between pneumococcus peritonitis and streptococcus. It is always very difficult to make the distinction by bacteriological examination, and undoubtedly many mistakes have occurred. This was well expressed for me by Dr. James G. Dwyer,<sup>30</sup> of Columbia University, as follows:

"The differentiation between pneumococcus and streptococcus of atypical morphology is a very difficult thing, unless we carry out the full identification of each by immune serum tests, by the use of inulin, bile, etc. If these tests are done, the differentiation is final and complete. If this is not done, there is always a legitimate question as to the differential diagnosis."

Three out of five of our Lebanon Hospital cases which were operated upon gave a clinical picture of pneumococcus peritonitis and that was the surgical diagnosis insisted upon by the operators, and yet the pathologists



pronounced the bacterium in each of these three cases to be streptococcus and not pneumococcus.

A case reported by Dr. Nathan Green<sup>31</sup> is very interesting in this connection. A child was operated upon for peritonitis and the bacteriological examination showed the presence of streptococcus. During convalescence the child developed a metastatic abscess of the thigh. Examination of this latter pus showed pneumococcus. Query: Do these cases illustrate the difficulties of bacteriological determination?

"A legitimate question as to differential diagnosis?" . . . Or do they indicate a possibility as to "The transmutations within the streptococcus-pneumococcus group."—E. C. ROSENOW.<sup>32</sup>

*Treatment.*—I feel that it is very important to touch upon this phase of the subject at the present time. Nearly every writer who has contributed to this subject has stated unequivocally that laparotomy is the proper procedure in all cases. A careful review of case reports, however, will show how little warrant there is for this assertion.

For instance, Annand and Bowen<sup>1</sup> claimed that early operation was the proper form of treatment, and yet their own analysis of 91 case reports showed a mortality of 86 per cent. in the cases of diffuse peritonitis. Some case reports have shown a mortality of 100 per cent. in operations performed in the diffuse cases. On the other hand, operation is undoubtedly the correct form of treatment in the encysted cases. Without going into this question more fully again, I think we can agree with those (Cameron,<sup>25</sup> Kahn,<sup>26</sup> and others) who feel that operation is not the proper form of treatment when the peritonitis is generalized and when the toxæmia is severe. Under these circumstances the treatment should consist in open-air, general support, the Fowler position if the pulse will stand it, proctoclysis, in other words, the Murphy-Ochsner treatment for peritonitis.

When the peritonitis is of the encysted form, or has become encysted, and when the extreme toxæmia and depression are lacking, or have materially subsided, operation is undoubtedly the proper form of treatment. The localized collections of pus should be evacuated and the case should be treated according to the same surgical principles as would apply, in similar cases, to other varieties of peritonitis.

The serum treatment should have the same place in pneumococcus peritonitis as it has in pneumococcus infections elsewhere. I believe at present we recognize serum treatment to be of value in cases which are caused by group I pneumococcus. This being so, as a matter of science one should determine the type of pneumococcus, and use a number 1 serum when it is known that the bacterium belongs to group I. As a matter of practice it may be good sense to administer the serum without waiting for the exact determination as to the group of pneumococcus. Should it belong to group I we may expect great benefit, and should it not, we would simply be running the risk of a certain amount of serum disease.

At Lebanon Hospital were found records of 8 cases which were fur-

nished to me as cases of idiopathic pneumococcus peritonitis. As these reports were somewhat unsatisfactory, I do not feel like putting them on record in detail, but I think it may be useful to say a few words concerning them.

As to sex—there were 6 females and 2 males. As to age—there were 3 patients over fifteen years of age, and 5 patients under fifteen years of age. All of the 8 cases were of the diffuse variety; 8 patients were operated upon; 5 died, 3 recovered.

Three of the 8 cases were not examined bacteriologically. Of the 5 cases studied bacteriologically, streptococcus was found in 3. Pneumococcus was found in 2 cases. The 3 cases in which streptococcus was found presented the clinical appearance and characteristics of pneumococcus peritonitis, and such was the clinical and surgical diagnosis. In fact, the surgeons insisted that these were pneumococcus cases but the pathologist adhered to his finding of streptococcus, not pneumococcus. In reading the detailed reports of these 3 cases I would feel that there may be some doubt as to the type of bacteria. Unless full tests are made differentiation between the pneumococcus and streptococcus is very difficult.

In conclusion let us sum up:

Idiopathic peritonitis does occur.

Pneumococcus peritonitis is a rare disease. Netter found it twice in 140 cases of peritonitis bacteriologically examined. In 104 pneumococcus infections in adults he found no case of peritonitis; in 47 such cases in children he found one case.

Pneumococcus peritonitis particularly affects girls. Under fifteen years of age the proportion is three girls to one boy.

Pneumococcus peritonitis may occur (1st) as a single lesion, *i.e.*, alone; (2nd) as a sequel to some other site of infection, as the lung, pleura, etc.; (3rd) it may be followed by invasion of other localities, lung, pleura, etc.; (4th) it may be a local manifestation of a general septicæmia. Probably it is always that.

Pneumococcus peritonitis is found in two forms: (1st) the diffuse; (2nd) the encysted. These forms may represent different types or varieties of the disease or they may represent different stages of the disease. This is yet to be demonstrated.

When the peritonitis is encysted the prognosis is good, spontaneous recovery may take place in one of several ways. Operation results in a high percentage of recoveries (86 per cent.).

When the peritonitis is diffuse the prognosis is bad—death is the rule. Operation results in very high mortality (86 per cent.; in some series 100 per cent.).

We recognize a symptom syndrome which should make diagnosis reasonably certain in typical cases.

Operation should not be performed in the diffuse form.

Operation should always be performed in the encysted form.

## PNEUMOCOCCUS PERITONITIS

The above represents the sum total of our present-day knowledge of this subject as set forth in the literature to date.

While I have nothing new to add to this subject, I feel that I may be performing a service by propounding certain questions which have not yet been answered. The satisfactory solution to some of these questions would go a long way toward improving our treatment of this disease.

### CERTAIN POINTS OF INTEREST AND IMPORTANCE WHICH ARE YET TO BE CLEARED

1. Why is the disease most common among children?
2. Why is the disease more common among girls than among boys?
3. How does the disease invade the peritoneum?
4. Is there a local port of entry?
5. Is there always septicæmia?
6. Will the blood always show pneumococcus? If not, in what per cent.?
7. Is the secondary form caused by blood infection?
8. Why is diarrhœa so frequently a symptom?
9. Is there commonly an enteritis?
10. Do the diffuse and encysted forms represent types of the disease, or do they represent stages?
11. If they are two different types of the disease, are they caused by different types or strains of pneumococcus?
12. Have pneumococci been classified in this and in other lesions, as they have been classified in pneumonias?
13. What can we hope from serum treatment in this disease?
14. Are the chlorides diminished in pneumococcus peritonitis as they are in pneumonia?
15. Will the administration of chlorides show the same benefit they have shown in the treatment of pneumonia?

Before closing, I will touch briefly upon some of these questions: The first four are really of academic interest, and will undoubtedly be answered more or less completely as time goes on.

5, 6, and 7 may be covered by one answer. There is undoubtedly always a bacteræmia; the peritonitis is really a local manifestation of a systemic infection. When peritonitis is secondary to some other lesion, as pneumonia, for instance, the disease doubtless reaches the peritoneum through the blood stream. Undoubtedly the blood should always show the presence of pneumococci. I cannot do better than to again quote the words of my friend, Doctor James G. Dwyer, to whom I put this question:

"The disease probably gains access to the peritoneum through the blood. It is probably always a bacteræmia, the organisms circulating through the blood and localizing in the peritoneum. Blood cultures if taken often enough, at the proper time and sufficient blood drawn, would be a valuable method of diagnosis on this point. A negative blood finding would have no meaning, as the mechanical and bacteriological reasons of why we get negative blood cultures when we should get positive hold good here. Blood cultures should show a bacteræmia."

10, 11, and 12 may similarly be expressed in one answer. Thus far the pneumococcus in its relation to peritonitis has not been systematically studied as it has in its relation to pneumonia, though some investigation along this line was made by Michaut many years ago.

Whether the diffuse peritonitis cases with extreme toxæmia represent a distinct type and are caused by a strain of pneumococcus of extreme virulence (group III) remains to be proven. It is a matter of the greatest importance and should receive the fullest possible investigation. For this purpose, bacteriologically, our peritonitis cases should be subjected to the most intensive study.

Serum therapy should have the same place here as it has in the treatment of pneumonia.

The questions as to the chlorides yet remain to be investigated and answered.

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## OBSTRUCTIVE (MALIGNANT) JAUNDICE

OPERATIVE RELIEF BY CHOLECYSTOGASTROSTOMY, ETC.

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"ALL cases of obstructive jaundice are entitled to operative consideration. There is a certain definite percentage of cases that are cured because there has been a mistake in the diagnosis. These operations are advised solely as palliative procedures and as such they perform must be clearly understood."

These above conclusions are found as number 1 and 5 in a recent article: "Relief of Chronic Obstructive Jaundice by Palliative Operation," by John F. Erdmann and Charles Gordon Heyd, *American Journal of the Medical Sciences*, August, 1916.

My clinical experience with this type of patient during the two years passed since the above mentioned article was written more than convinces me of operative procedure. Reviewing the literature of obstructive jaundice and recalling the material presenting itself in our large hospitals, renewed suggestions for operative relief of chronic cholæmia within two years I hope may not be amiss.

I am considering, therefore, those cases of biliary and pancreatic obstruction, with or without duodenal involvements, incident to malignant disease or irremovable tumors about the terminal portion of the common and pancreatic ducts.

As persistent and increasing jaundice is in the large majority of cases due to malignant disease, what can be done in the way of palliation for these patients should be considered. Little comment is necessary to describe the clinical picture of chronic obstructive jaundice. The rapid loss of weight, emaciation and asthenia, pruritus and disturbing mental conditions incident to cholæmia often render attempts at operative relief imperative. The mechanical factors evidenced in organic occlusion extrinsic to the common duct but still within the head of the pancreas, or those intrinsically of the duodenum, *i.e.*, those growths of the ampulla of Vater, etc., will by their anatomic position enable one to establish such operative procedure best fitted for relief.

Without question it follows that relief to biliary stases must be provided by operative drainage between some portion of the biliary apparatus and the gastro-intestinal tract, or by an opening into the biliary tract communicating with the outside world; this latter, while having been an operation of choice formerly, must be excluded from our present-day operative procedure for more reasons than that of soiling the surroundings. Chief among these is the physiological loss of biliary salts, etc.

Indications for operation in malignant obstruction to the flow of bile are:

1. Possible mistaken diagnosis, as not infrequently an operator for sup-

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posed malignancy finds a benign condition which is rapidly corrected by instituting drainage, etc. These are the patients in whom we obtain so-called cure from malignancy. Moynihan aptly says: "No one living is infallible in the differential diagnosis of obstructive jaundice. The diagnosis is always so difficult and the chance of a life saved so important that however positive the evidence of malignancy may be, I now advise operation in all cases."

2. The relief of distress in pain (back pressure upon the biliary system): Some patients complain of this symptom only. All do not suffer from pruritus, or the mental states.

3. Pruritus of an intractable degree or nature: In many patients this symptom is so severe that the patient demands operative relief. I have had them threaten suicide if operation was refused.

4. Social or business: To prolong life in comparative comfort; to give the patient relief from his jaundice and pruritus so that he may live with his family or conduct his business until such time as death takes place from metastasis, exhaustion, etc. This has been demonstrated in several of my patients recently, two living two years in comfort and able to attend to their business to within a short period of their deaths.

5. Surgical euthanasia: The primary operative mortality in these conditions will be high, but considering the absolutely hopeless outlook, together with the urgent demand for relief, one is warranted in selecting an operative procedure.

A neoplasm at the ampulla of Vater, by kinking the duct or by pressure œdema of the mucous membrane of the duct, or by extension into the duodenum, will bring about not only biliary, but also pancreatic obstruction of variable degree. The duct of Wirsung carries the entire pancreatic secretion in about 83 per cent., while the duct of Santorini is the main duct in 12 per cent. In 54 per cent. the duct of Santorini acts as a substitute for the duct of Wirsung. In certain cases the duct of Santorini remains uninvaded for a long period of time. Again, the duct of Santorini not infrequently connects with the duct of Wirsung; in these patients complete biliary stasis exists, while pancreatic drainage into the duodenum is not evidenced. While this is likely to be a rarity, aside from theoretical interest, it presents no technical interest over the usual case.

Cholecystenterostomy will deliver the biliary secretion into the intestinal tract. The stools will then contain bile, and the bile disappears from the skin and urine; but this operation could, however, only rarely affect the pancreatic, and in the few cases that it did influence, pancreatic drainage would depend upon retrograde flow into the common duct, then into the cystic and then through the gall-bladder into the intestines.

Most of the patients suffer from a lack of pancreatic secretion in the intestines with a lack of pancreatic digestion, evidenced by bulky, frequent stools, showing an increase in the amount of fats and changed relationship between saponified and unsaponified fats, and the absence of adequate protein digestion. Therefore, these cases may proceed to a rapid death as a result of

this pancreatic deficiency, although the elimination of jaundice and biliary stasis has been accomplished by cholecystenterostomy.

Chronic obstruction of the duodenum below the ampulla of Vater will give in addition to biliary stasis the signs of pyloric obstruction. Two of my cases, one a young man of seventeen years, gave the dual picture clinically of pyloric obstruction and biliary stasis. It is usual to find the distended gall-bladder of Courvoisier accompanying obstructive conditions in the distal portion of the common duct; occasionally instead of the bladder being filled with bile, as is usual, the contents have been observed by myself and assistants to be cystic in character. This is explained by Kausch, quoted by Outerbridge, as a pressure acholia. The common hepatic and cystic ducts are filled with the same type of clear mucoid fluid. In Kausch's patient, after drainage had been established a few hours, the discharge began to assume a biliary stain. In six hours, almost pure bile flowed and continued so until death. Autopsy showed a carcinoma of the papilla of Vater. He (Kausch) thought this hydrops in these patients due to excessive mucus secretion in the gall-bladder and ducts; the duodenal opening being closed or impervious, that the biliary secretion, then due to pressure in the biliary system, being so raised that the secreted bile is poured back into the blood- and lymph-vessels of the liver.

The most frequent cause of obstructive jaundice is carcinoma of the pancreas, ampulla or duodenum. Cancer of the duodenum represents about 0.4 per cent. of all carcinoma, and of these about 70 per cent. are of the ampulla of Vater. Pancreatic cancer is the most fatal of any form of carcinoma; death ensues from seven to eight months from the onset of noticeable symptoms and occurs before metastases obtain any great extension. Upcott, p. 717, says there is probably no position within the body outside the central nervous system where a growth, while yet so small, is heralded by more widespread symptoms than at the lower end of the common duct. Excision of growths at the ampulla is rare and the results not encouraging. Of 22 such cases reported up to about November, 1915, 8 primary and 5 subsequent deaths occurred. Of 5 surviving any length of time, 2 were well at seven months, 1 ten months, 1 two years, and 1 at three and three-quarters years.

*Operative Consideration.*—Recall that I have specifically stated that these operations in the main are palliative; therefore given an obstruction to the common duct, or its terminus, the ampulla of Vater, we have a variety of operations to choose from.

The simplest—cholecystostomy as stated above—is not to be considered, except as a primary step, as this operation, through loss of biliary salts and body fluids, including the pancreatic juices in some patients, is likely to be followed by a rapid demise. Whereas, in an anastomosis with some portion of the gastro-intestinal tract all the afore-mentioned secretions are retained. Anastomoses between the hepatic duct and some contiguous organ, while theoretically easy, are practically very difficult and accompanied by an increased mortality.

The choice of operations depends upon numbers of factors, as, (1) physiological efficiency; (2) ease of accomplishment; (3) immunity from ascending infection; (4) effects immediate and remote on the patient's metabolism. Cholecystoduodenostomy will more nearly simulate the normal or rational condition of biliary drainage. Owing to the fixity of the duodenum in many patients this operation is accompanied with a greater degree of difficulty in technic and also therefore by a greater mortality than a cholecystogastrostomy. The operation of cholecystogastrostomy was performed by Moynihan 21 times; 20 patients recovered from the operation and lived for several months or years, without suffering disability which could be attributed to the entrance of the bile into the stomach. My own experience in this operation bears out the above. I have not seen one patient in whom I have done the operation where any untoward symptoms presented. On the contrary, all felt relief from the previous symptoms in from one to three days. I have performed cholecystogastrostomy 18 or 20 times during the past four years—in two of these patients adding a posterior gastro-enterostomy, owing to a carcinoma of the papilla of Vater, producing duodenal obstruction.

Considering the merits of cholecystogastrostomy, cholecystenterostomy, cholecystoduodenostomy and cholecystocolostomy proves that the best results are obtained with cholecystogastrostomy. Physiologically no objection to the presence of bile in the stomach has been demonstrated. Technically this operation is more easily performed than any other of the recommended procedures, as the structures in this type of anastomosis are intimately associated and of easy access, little or no mobilization being required. Cholecystenterostomy carries with it the possibility of a later angulation, and an accompanying entero-enterostomy on the loop of the intestines—this added operation being a source of added risk and mortality.

Cholecystoduodenostomy frequently presents difficulties of depth in the anastomosis and occasionally extensive adhesions work to bring about difficulties of mobilization for suture. Cholecystocolostomy has been done by me twice. In both instances it was an operation of expediency, due to massive adhesions and inability to thoroughly expose either stomach or small intestines. This operation is contra-indicated because of (1) the possible reflux of the high bacterial charged content of the colon; (2) the possibility of reversed mucus currents, described by Bond; (3) the loss of digestive functions of the bile, especially the saponification of fats; (4) the fact that the bile is so soon lost in the stools may mean a rapid loss of the salts of the bile which would normally be reabsorbed in the intestine in the event of a higher anastomosis. Nevertheless, it is rather instructive that my first cholecystocolostomy, done in a patient over seventy, accomplished all the desired results, the patient living over seven months, being carried off by an acute cardiac lesion. During the past year I operated upon a patient who entered Gouv-erneur Hospital in shock with a scar over his duodenal zone, a board-like abdomen, inability to give any history. An emergency operation was done, thinking that he had a perforated duodenal ulcer. Upon exposing the contents in the upper right quadrant, exudate and adhesions in plenty were



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found. No free fluid, etc., was found in the abdomen, but a greatly distended gall-bladder with its fundus attached to the transverse colon was exposed. Upon dissection it was easily demonstrated that a cholecystocolostomy had been performed. The bladder contents could not be emptied into the colon. Upon separating the bond of union and investigating, it was observed that the gall-bladder was filled with fluid feces and a large piece of fruit skin, possibly from a prune, was occluding the artificial opening in the gall-bladder. The contents of the gall-bladder were cleaned out, the opening into the colon closed and the gall-bladder then anastomosed to the stomach. There were no after symptoms of any untoward nature, although the drainage from the liver ducts and the gall-bladder must have been highly toxic for several days. Subsequent questioning of our recovered patient elicited the facts that he had been operated upon in one of our large city institutions for an obstructive jaundice about eight months before.

My youngest patient was seventeen years of age, while my oldest was over seventy. Hepaticoduodenostomy was done but once. In this patient, owing to a malignancy at the cystic duct junction, no other operation was possible. The hepatic duct was dilated to fully the size of one inch in diameter, thereby facilitating the anastomosis.

# ACUTE AND SUBACUTE PANCREATITIS\*

REPORT OF SEVEN CASES

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ALTHOUGH acute pancreatitis with fat necrosis was first described by Balser in 1882, it was not until the appearance of Fitz's classical papers in 1889 that the interest of the medical world was aroused, and inflammatory diseases of the pancreas began to be studied clinically and in the laboratory. Inasmuch as such cases are rather rare, animal experimentation has proved of the greatest benefit in elucidating many problems connected with them. This is particularly true of the acute inflammations of the pancreas, for the chronic conditions do not lend themselves well to animal experimentation. Our knowledge of chronic pancreatitis is, therefore, largely the result of observations made at the bedside and in the course of operations upon the biliary apparatus.

*Etiology of Acute Pancreatitis.*—Acute hemorrhagic pancreatitis is said to occur more frequently in men than in women, the proportion being about two to one, but five of my cases were women and two were men. With few exceptions the disease occurs between the ages of twenty and fifty years; obesity and alcoholism are believed to favor its occurrence. About 1901 Opie, whose name is prominently associated with our knowledge of all conditions affecting the pancreas, performed an autopsy upon a case of acute pancreatitis, which had been operated by Halsted, and discovered in the ampulla of Vater a small gall-stone, about 3 mm. in diameter. If we recall the anatomy of the pancreatic ducts and the common bile-duct, we will find that in a large number of cases, perhaps 40 per cent., the duct of Wirsung joins the common duct in the ampulla a few millimetres above the papilla. In Opie's case the stone was large enough to occlude the opening of the common duct at the papilla, but not sufficiently large to, at the same time, occlude the opening of the duct of Wirsung. Inasmuch as Opie found the pancreatic ducts somewhat distended and bile-stained, he concluded that the small stone had occluded the opening of the ampulla of Vater into the intestine and had caused a retrojection of bile into the pancreas, the acute pancreatitis resulting; moreover, he showed that a typical acute pancreatitis could be produced in animals by the injection of bile into the pancreatic ducts, just as it had been shown by Flexner and others that the injection of various substances, such as artificial gastric juice, dilute acids, oils, etc., would produce an acute pancreatitis. The physiologic investigations of Pawloff and his pupils have shown that under normal conditions the pancreatic juice is inactive, but is activated by enterokinase, by

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which trypsinogen is changed to trypsin. When this occurs within the gland digestion takes place and the enzymes are liberated into the gland and surrounding tissues, extensive necrosis resulting. Among other substances in the body, which seem to be able to activate the pancreatic juice, are: the duodenal contents, bacteria, blood serum and bile, especially when infected. Polya has called particular attention to the important part played by bacteria in activating the pancreatic juice in cases of acute pancreatitis.

Since the above case was published by Opie, several other cases have been reported in which almost identical conditions were found, and in one of my own cases a small stone was found occluding the outlet of the ampulla. Many cases have been reported in which acute pancreatitis has been associated with gall-stones in the gall-bladder and in portions of the common duct other than the ampulla. In a large series of cases of acute pancreatitis collected by Egdahl, gall-stones were found in 42 per cent. of the cases, and in 50 per cent. of a series of forty-four cases, reported by Körte, disease of the gall-passages was present. In 5 of my 7 cases gall-stones were found. In a certain number of cases the duct of Wirsung enters the intestine independently and does not join the common duct, and in such cases the presence of gall-stones is probably of little importance in the production of acute pancreatitis. Pancreatic stones are sometimes the cause of acute pancreatitis. According to Egdahl, gastro-intestinal disorders are, next to gall-stones, the most important cause of acute pancreatitis. In his series of cases, 32, or 30 per cent., belong to this group, and 17 of the 32 cases gave a history of alcoholism. He thinks that perhaps the gastroduodenitis may cause an occlusion of the papilla of Vater and a retrojection of bile into the pancreas.

Acute pancreatitis may be caused by a good many other conditions, such as typhoid fever, mumps, trauma, gastric ulcer, appendicitis, syphilis, etc. We do not wonder that typhoid fever may be a causative factor in the production of acute pancreatitis, as we all know the proneness of typhoid bacilli to lurk in the gall-bladder and bile-passages even many years after the attack of fever. Moynihan has recorded a case of acute pancreatitis in which typhoid bacilli were found in the pancreas. A good many cases have been reported in which mumps was complicated by acute pancreatitis, and this is not surprising when we consider the similarity in structure of the pancreas and the salivary glands; in fact, the pancreas is called by the Germans the abdominal salivary gland. In such cases the symptoms are usually milder than in other cases of acute pancreatitis and a good many have recovered without operation.

Although it is possible for bacteria to cause acute pancreatitis by activating the enzymes of the pancreas, they are probably in most cases secondary invaders. The organism most commonly present in acute pancreatitis is the bacillus coli communis, as we would expect, since it is a normal inhabitant of the intestinal tract; next in frequency are the streptococci and staphylococci. It is not definitely known how these organisms gain access to the pancreas, but it seems undoubtedly true that they sometimes pass

from the bile-passages into the pancreatic duct, sometimes directly from the intestine into the pancreatic ducts, sometimes by the blood-vessels and lymphatics, or directly through the intestinal wall into the pancreas.

*Pathology of Acute Pancreatitis.*—The pancreas, involved in acute pancreatitis, is usually found to be greatly swollen and its consistency is usually softer than normal, especially where the hemorrhagic infiltration and necrosis are extensive. It presents a dark reddish, mottled appearance, and, on microscopic examination, we find areas of necrosis, which stain poorly with the aniline dyes. About these necrotic areas there is a zone of inflammation and scattered through the involved gland there are more or less extensive areas of hemorrhagic infiltration. Sometimes the whole pancreas seems to be nothing but a mass of necrotic tissue.

There has been a good deal of discussion regarding the relationship between pancreatic apoplexy, the ultra-acute cases of Mayo Robson, and ordinary hemorrhagic pancreatitis, and the question is not yet definitely settled. Some think that hemorrhage can take place without previous inflammation, others think that inflammation always precedes the hemorrhage. It seems to me that in certain rare cases the hemorrhage may be due to the rupture of an arteriosclerotic vessel without previous involvement of the pancreas, but in most of these cases we are dealing with a very acute pancreatitis, the digestion of the vessel walls giving rise to the marked hemorrhage. Draper, of Boston, called particular attention to this so-called pancreatic apoplexy as a cause of sudden death.

The fat necroses which accompany acute pancreatitis are of considerable interest. It is now shown that they are due to the presence of the fat-splitting ferment, steapsin, in the tissues and Flexner has proved the presence of steapsin in these areas of fat necrosis. These areas present a peculiar yellowish-white appearance and are really areas of saponification as the neutral fat is split into glycerin and fatty acid, the latter combining with calcium in the tissues to form soap. They are of considerable importance, as their presence in the course of an operation always points to trouble in the pancreas.

The bloody fluid in the peritoneum in cases of acute pancreatitis has been considered by many to be quite toxic, and Guleke, who attributes its toxicity to the presence of trypsin, claims to have produced death in animals by its injection. On the other hand, this is disputed by Whipple, who has injected the fluid into the peritoneal cavity and veins of healthy dogs and dogs quite sick with acute pancreatitis, without producing any bad effect. He even believes that the exudate may neutralize the ferments and be beneficial, and thinks that operations undertaken with a view to draining it off are ill advised.

*Symptoms of Acute Pancreatitis.*—One of the most striking symptoms of acute pancreatitis is the acute agonizing pain in the epigastrium, which is so extreme that it may rapidly bring on collapse and may actually cause syncope. It is more or less constant but may be paroxysmal; it tends to remain in the epigastrium but may radiate to the left. Vomiting soon

occurs and is so persistent that, together with the obstinate constipation, it has frequently led to the mistaken diagnosis of intestinal obstruction. The constipation is almost absolute, though enemata may bring away a little gas. If the patient survives the acute stage and passes to the subacute, diarrhoea may follow the constipation. Distention of the abdomen is a prominent feature in this disease and first appears in the upper abdomen, as in one of my cases, where it seemed to be due to the direct effect of the inflammatory products upon the transverse colon; but later the distention becomes general. Tenderness is present in the upper abdomen, but the tenderness and rigidity are usually not extreme. The character of the pulse may be of value in the diagnosis of this disease, as it becomes rapidly weak and small. The temperature is not of a great deal of significance; it may be normal, subnormal or elevated to  $103^{\circ}$  or  $104^{\circ}$ . In the very acute cases it is apt to be normal or subnormal; whereas in the subacute cases it is likely to be high. Glycosuria as a symptom of pancreatic disease usually occurs late and with advanced destruction. It was found in none of my cases.

The various functional tests for disease of the pancreas are, generally speaking, not very satisfactory and are chiefly applicable in the chronic affections of the gland. The much discussed Cammidge reaction seems to be almost worthless, and the results of the estimation of the amount of diastase in urine in these conditions have proved rather disappointing. Crohn has recently studied the duodenal contents, removed by means of the Einhorn duodenal tube, in 120 cases, of which 17 had pancreatic involvement, and has also made careful metabolism studies on the fat and nitrogen absorption from the intestine in seven cases of pancreatic disease. The following are his very interesting conclusions:

1. The quantitative examination of duodenal ferments is the most rational and accurate method of studying the external secretion of the pancreas. Diminution of such enzyme activity of the pancreas is a reliable sign of organic disease of the gland. Occasionally, though rarely, a diminution of ferments occurs as a symptom of advanced organic disease elsewhere in the body. Roughly, the diminution of ferments is directly proportional to the extent of organic destruction which has taken place.

2. The absorption of fat and nitrogen from the intestine is independent of the condition of the external secretion, or even of its presence. Absorption may be poor with an intact gland, or good with a gland of which only a fragment survives the disease. The functional activity of the gland, not its organic condition, determines the degree of absorption; this is probably controlled by an internal secretion or hormone.

3. Duodenal ferment tests give the index of the organic condition of the gland. Absorption tests give the index of the functional activity of the pancreas.

Death usually occurs in from two to five days from collapse, though in the less acute cases life may be prolonged or recovery may even take place. There has been considerable discussion regarding the cause of death in acute pancreatitis. The theories of shock, due to the involvement of the solar plexus, and of sepsis do not hold. It has been shown that it is due to a toxæmia. For a time it seemed as though Hess were right, when he maintained that the toxæmia in pancreatitis was due to the formation of soap

and its absorption. By injections of oil and paraffin he produced a picture very similar to that of pancreatic apoplexy. This view was, however, challenged by Guleke and v. Bergmann, who showed by their experiments with implantation of the gland that the toxic substance is in the gland itself, apparently in the trypsin, for the commercial trypsin of Grüber had the same effect; moreover, they claimed that after previously immunizing an animal with trypsin, the production of pancreatic necrosis was not necessarily fatal. Doberauer, who in general holds this view, does not, however, think that the toxic substance is in the healthy gland, but that it is a product of the decomposition of the gland cells, caused by the self-digestion, which occurs in acute pancreatitis. It seems that Guleke and v. Bergmann now agree with Doberauer, and think that the toxæmia of acute pancreatitis is due to the absorption of the products of cell decomposition, caused by self digestion. Whipple thinks that a proteose intoxication is the most important factor in the general intoxication of acute pancreatitis, just as it is in intestinal obstruction.

*Diagnosis of Acute Pancreatitis.*—The diagnosis of acute pancreatitis is difficult, as the symptoms at first are only characteristic of a peritonitis beginning in the upper portion of the abdomen. It seems to me that this peritonitis is chemical and not infectious in the early stages of the disease. If we bear in mind the pancreas, when we meet with a stormy process in the upper abdomen, suggesting a perforative peritonitis or high intestinal obstruction, more cases of acute pancreatitis will be correctly diagnosed.

In general the differential diagnosis must be made from intestinal obstruction, and peritonitis, resulting from a perforated gastric or duodenal ulcer, a ruptured gall-bladder or appendix. The diagnosis is often impossible and is of consequence chiefly in regard to the nature of the incision as all of the above conditions demand operation. After the incision is made the presence of the serosanguineous fluid in the peritoneum and disseminated fat necroses clinches the diagnosis. However, a previous history of gastric disturbances with acid eructations or the vomiting of blood, together with extreme tenderness and rigidity in the upper abdomen, a rapid obliteration of the liver dulness, due to the presence of free gas in the peritoneal cavity, and perhaps a higher temperature and leucocytosis than in the usual case of acute pancreatitis, would indicate a perforated gastric or duodenal ulcer.

In case of intestinal obstruction the pain would probably be more paroxysmal in character, quite severe, but probably not so severe as that of acute pancreatitis, and whereas the collapse is rapid in acute intestinal obstruction it hardly comes on so rapidly as in acute pancreatitis. Moreover, on careful observation peristalsis will probably be seen in acute obstruction, whereas it is not present in acute pancreatitis, as here the obstruction is adynamic in nature. The history of the case, with a careful examination of the patient, will often permit us to distinguish between a peritonitis resulting from the rupture of an appendix or gall-bladder and an acute pancreatitis.

*Subacute Pancreatitis or Pancreatic Abscess.*—These conditions are of

especial interest, as they are particularly amenable to surgical treatment. They really represent the later stage of an acute pancreatitis which has probably had an onset just as acute as those which we have previously discussed, but, as a rule, the symptoms have not been so severe. The patient survives the acute attack, but he continues to complain of gastric disturbances, has more or less pain in the epigastrium, runs a temperature and gradually loses ground. Examination may show the presence of a tender tumor in the epigastrium.

*Treatment of Acute Hemorrhagic and Gangrenous Pancreatitis.*—Although the question as to the best treatment of acute pancreatitis has been freely discussed in recent years, it is not yet settled. Many surgeons are still averse to early operation, arguing that, inasmuch as the results of operative interference are more favorable after the formation of a localized abscess, one should wait until such an abscess forms before operating. This argument, however, is fallacious, as it does not consider the large percentage of those who die before such a favorable condition is presented; and, in the second place, many patients never develop a localized abscess, the process being diffuse from the beginning.

A number of surgeons, among them Körte, who formerly advised against operation in the early stages, now advise early operation. One of the first to advise operating in the first stages of acute pancreatitis was Hahn, who, considering the collapsed condition of most of these cases, recommended a small incision in the midline below the umbilicus and drainage for the evacuation of the blood-stained peritoneal fluid. He thought the high mortality after operation in such cases was, to some extent, due to the fact that the operation was undertaken with the mistaken diagnosis of peritonitis or intestinal obstruction, the prolonged search for the perforation or obstruction being badly borne by such weak subjects. This point has also been emphasized by Mikulicz and others. Woolsey, who has reported three cases operated upon in a manner essentially similar to Hahn's, with recovery, recommends laparotomy and drainage, and thinks extensive and prolonged operations are not justifiable. Pels-Leusden, Wiesinger, and others have reported cases thus treated successfully.

Halsted, Pels-Leusden and Bevan have reported cases of acute pancreatitis which recovered after laparotomy and closure without drainage. In some of these cases nothing more was done because the collapsed condition of the patient would not allow it. The benefit derived from these methods of operating has been thought to be due to the removal of the blood-stained peritoneal fluid, which has been considered very toxic, but, as stated above, Whipple has apparently proved that the effusion is harmless. Mikulicz in 1903 advanced the view that acute pancreatitis should be treated as any other phlegmon, and that the moment the condition is recognized the abdomen should be opened and the inflamed peripancreatic tissues and the pancreas itself incised and drained. He considered the flushing of the abdominal cavity with salt solution to be quite important. Porter and Muspratt have reported cases successfully treated by this method, deep incisions being made

into the pancreas and drainage instituted. A study of the literature reveals the striking frequency of the sequence of acute pancreatitis upon cholelithiasis, and a good many cases are recorded in which at the operation for acute pancreatitis gall-stones were found in the gall-bladder and cholecystostomy performed, the patient recovering completely.

I want to emphasize the importance of operating in the early stages of acute pancreatitis, before a secondary infection from the intestine renders the prognosis more unfavorable. Inasmuch as these cases are seldom diagnosed with absolute certainty and are often mistaken for peritonitis or intestinal obstruction, the operation will usually be in the nature of an exploratory laparotomy. The discovery of blood-stained fluid and the presence of fat necroses clinch the diagnosis.

The exact nature of the operation will depend upon the condition of the patient. The ideal procedure would be about as follows: Rapid exposure of the pancreas through the gastrocolic omentum, incision of the swollen, inflamed gland, and the introduction of a large gauze drain; examination of the gall-bladder and bile-ducts; removal of calculi, if present, and cholecystostomy. As a matter of fact, such a procedure may often be unwarranted and must be modified to suit the case.

Mikulicz in 1903 collected 46 cases of acute pancreatitis, which had been operated upon in the acute stage, with only 9 recoveries. On the contrary, 18 out of 35 cases recovered when the operation was done in the later stages. He states, however, very rightly that such statistics are of very little value, for, as he says: "First of all, we do not know from the statistics available at present how many of these patients with acute pancreatitis really survive the acute stage and go on to the subacute, the most favorable stage for operation. I believe that comparative statistics in this regard will show that the great majority of the patients die in the acute stage. The possibility that a goodly number could be saved by a rationally conducted early operation cannot at present be denied."

Bloodgood in 1904 collected 75 cases of acute hemorrhagic pancreatitis, of which 25 recovered and 50 died. Of the 25 which recovered, 18 had been operated upon, the remaining 7 recovering without operation. Of the 50 which died, 23 had been operated upon. Most recent statistics of operations for acute pancreatitis give the mortality as 50 to 60 per cent.

Körte in 1912 reported 44 cases of acute pancreatitis, of which 34 occurred in his own division in the Krankenhaus am Urban and also in his private practice, while 10 cases came from the second surgical division of this hospital and were seen and reported by Brentano. Of the 44 cases 38 were subjected to operation. In 6 cases no attack was possible. Of the 38 cases operated upon, the diseased pancreas was directly attacked in 34, while in 4 cases only the concomitant disease of the gall-passages received operative treatment. Of the 34 operated patients, in which the diseased organ was immediately approached, 18 recovered and 14 died, a mortality of 47 per cent. Of 12 cases operated upon in the first week after the beginning of the illness, 8 recovered and only 4 died.



*Treatment of Suppurative Pancreatitis: Pancreatic Abscess.*—Those cases of acute pancreatitis which proceed to suppuration, the subacute form of Robson and Moynihan, are of particular interest, since they are especially amenable to surgical treatment. In the majority of these cases the onset is as acute as in the hemorrhagic form, but the symptoms are, as a rule, less severe, and the process is not of sufficient extent and gravity to cause death. Somewhat later the necrosis and secondary infection give rise to the formation of more or less extensive abscesses, containing larger or smaller portions of the sequestered pancreas. Considering the satisfactory results of prompt surgical intervention, the early diagnosis of these cases is very important, especially since grave complications are prone to arise, such as liver abscess, subphrenic abscess, thrombosis of the portal vein, exhaustion, etc.

Diffuse suppuration or abscesses confined to the pancreas are seldom seen, since the pus is very liable to burrow into the peripancreatic tissues and lesser peritoneum, often giving rise to a tumor, which can be more or less clearly defined before operation and which facilitates the diagnosis. The tumor usually presents in the midline below the stomach, but occasionally above the stomach, or it may extend over into the left flank, giving rise to the mistaken diagnosis of perinephritic abscess.

Spontaneous healing without operation is unusual, but cases where the diagnosis was confirmed have been recorded, in which recovery took place after the rupture of the pancreatic abscess into the intestine. Robson has reported such a case, and another in which the abscess ruptured into the stomach and recovery followed a gastro-enterostomy.

Cases of diffuse suppuration or small multiple abscesses offer little hope of successful surgical treatment, but with a large localized abscess the outlook is much brighter.

The diagnosis is often not determined until the abdomen is opened. The incision is usually made in the median line or through the rectus muscle over the most prominent part of the tumor mass. If the examination shows the presence of a pancreatic abscess, the abdominal cavity is packed off with gauze and the abscess opened, usually through the gastrocolic omentum, evacuated and drained with gauze or by means of a rubber tube surrounded with gauze. It is generally preferred to complete the operation in one stage, but it can be done in two stages, the abscess first being walled off with gauze or by suturing its walls to the parietal peritoneum and opened later, after adhesions have formed. To secure better drainage, especially when the abscess extends well toward the flank, it is sometimes advisable to make an incision in the costovertebral angle, and by blunt dissection, passing in front of the lower pole of the kidney, to open a path for drainage.

In recent years numerous cases have been reported in which recovery followed operations for pancreatic abscess. Thayer has reported 4 cases operated upon by Halsted, Finney, and Bloodgood, 3 of which recovered. Robson has reported 8 cases occurring in his own practice. Six were oper-

ated upon, with recovery from the operation in 5, though in 1 of the cases the relief was only for a few weeks and in another for a few months.

## REPORT OF CASES

The following seven cases were operated upon in my service at the University of Virginia Hospital.

**CASE I.**—T. J., male, aged fifty-one years, was admitted to the hospital, April 29, 1909, complaining of abdominal pain and vomiting. *Family history:* Unimportant. *Personal history:* Owing to the urgency of the case very little of his previous history was obtained. He stated, however, that he used very little alcohol.

*Present Illness.*—Patient was taken sick suddenly, thirty-six hours ago, with severe pain in the epigastrium, where it remained twelve hours, then moved downward, but has never settled on the right side. He vomited shortly after onset of illness and has vomited frequently since. Bowels were obstinately constipated, but moved with the aid of large doses of salts and a big enema of olive oil. Patient says that he has suffered for the last few years with acid eructations, for which he has taken soda, but has never vomited except with headache. He has not vomited any blood.

*Examination.*—The patient, who is rather stout, looks ill. Pulse 132 to the minute, temperature 101 per rectum, leucocytes 20,000. Sclerotics are bile stained. The abdomen is considerably distended and the central portion is blistered by applications. On palpation there is some general abdominal tenderness, most marked around the umbilicus, though, according to his statement, eight hours ago it was most marked in the appendix region. No mass felt. Liver dulness reaches to within 3 finger breadths of the costal margin of the right nipple line. The urine was not examined. No definite diagnosis was made before operation, but an acute pancreatitis was suggested as a possibility, the pronounced shock in such a short time and the bile staining of the sclerotics strengthening this opinion.

*Operation.*—There was considerable trouble during the anæsthetization on account of vomiting of large quantities of black fluid. An incision was made through the upper portion of the right rectus muscle. A considerable amount of bloody fluid was found in the peritoneal cavity, which immediately suggested an acute pancreatitis. A piece of omentum was then sought for and found to be studded with fat necroses, clinching the diagnosis. The pancreas was palpated and found to be greatly thickened and poorly defined. No stones were felt in the gall-bladder or ducts. The patient's condition was so bad that it was not thought advisable to explore the pancreas, so an iodoform and protective drain was placed in the lower end of the wound, which was closed with through-and-through silkworm-gut sutures. At the end of the operation an intravenous infusion of salt solution was given, which improved his condition somewhat. The improvement was, however, only temporary, and he died six hours later.

*Autopsy.*—A complete autopsy was not allowed, but the liver, pancreas, duodenum, gall-bladder and ducts were removed through the

operative incision. The pancreas was everywhere enlarged to twice its normal size, presented a reddish mottled appearance, with marked hemorrhagic infiltration and areas of necrosis. The pancreatic ducts were not bile-stained and there was no stone in them. The gall-bladder was somewhat distended but no stones were found in the gall-bladder or ducts. There was a large amount of mucus in the duodenum, but no particular reddening of the mucosa. In this case, therefore, no definite etiological factor for the acute pancreatitis was discovered.

**CASE II.**—Mrs. M. S., aged fifty-five years, was admitted to the hospital May 26, 1909, complaining of attacks of pain in the right hypochondrium accompanied by nausea and vomiting. *Family history:* Unimportant. *Personal history:* Has had all the usual diseases of childhood. Had diphtheria when a girl and pneumonia fifteen years ago. Has never had typhoid fever, has been generally healthy except for her present complaint. She suffers somewhat from shortness of breath on exertion and her ankles are sometimes a little swollen. Menses began at twelve years of age and have always been regular. Has had two children. Labors normal.

*Present Illness.*—For twenty years she had irregular attacks of pain in the right hypochondrium. Last fall, seven or eight months ago, these attacks were unusually severe. They would come on suddenly, after some indiscretion in diet, would last from one to six hours and were usually accompanied by nausea and vomiting. The pain would begin in the right hypochondrium and radiate toward the umbilicus. Two months ago the attacks began again with equal severity and have recurred at frequent intervals to the present time.

*Examination.*—Patient is a well-nourished, healthy-looking woman, color good. No jaundice of sclerotics. Pulse good quality, 90 to the minute, temperature 100. Examination of lungs, heart and urine negative. The abdomen looks natural, no mass seen. On palpation a mass the size of an orange can be felt beneath the right rectus muscle, extending from the costal margin to the level of the umbilicus. The mass is smooth, rounded, slightly tender and descends little, if at all, on inspiration. The rest of the abdomen is negative. Liver dullness reaches the costal margin in the right nipple line. The mass was thought to be most likely a hydrops of the gall-bladder.

*Operation.*—Incision was made through the upper portion of the right rectus muscle. As soon as the peritoneum was opened it was seen that the mass, mentioned above, was not the gall-bladder, but was situated behind the gastrocolic omentum in the region of the head of the pancreas. The gastrocolic omentum over the mass showed numerous fat necroses, was adherent to the parietal peritoneum in places, and over the apex of the swelling had a dark discoloration. The mass, which was about the size of an orange, was smooth, elastic and actually fluctuant. A diagnosis of pancreatic abscess was made. The gall-bladder was palpated and found to contain a large stone, otherwise the gall-bladder seemed normal, not unduly distended. The gall-bladder was opened and a stone 3 by 4 cm. in diameter removed. Cultures were made from the bile and proved to be sterile. A rubber tube was sutured into the gall-bladder for drainage. The abscess was

opened at its most prominent part and a large amount of purulent fluid and necrotic tissue evacuated. A large rubber tube was placed in the abscess and gauze packed about it. The abdominal wound was partly closed with through-and-through silkworm-gut sutures. Cultures were made from the abscess and the staphylococcus aureus isolated.

*Post-operative Course.*—The patient did well after the operation but discharged considerable quantities of necrotic tissue. She was discharged from the hospital about one month after the operation in good general condition, but the fistula was still discharging somewhat and continued to do so for several months after she left.

CASE III.—M. K., male, aged thirty years, was admitted to the hospital September 12, 1909, complaining of severe pain in the abdomen. *Family history:* Unimportant. *Personal history:* Patient has had the usual diseases of childhood and, at the age of ten, a severe attack of diphtheria, from which his recovery was slow. Four years ago he had a bad attack of typhoid fever and about three years ago a frontal sinus abscess, for which he was operated. Since that time his health has been fairly good, with the exception of an occasional bilious attack. He has indulged in alcohol but not to excess.

*Present Illness.*—Began eighteen hours ago, with severe constant pain in the epigastrium, somewhat worse to the left. He vomited shortly after the onset of pain and has vomited frequently to the present time. Bowels have not moved in spite of frequent cathartics and enemata. He was brought in with a diagnosis of intestinal obstruction.

*Examination.*—Patient is a well-nourished man, seems to be in great pain, but does not look extremely ill. Color is good, no cyanosis, sclerotics are not bile stained. Pulse is of good volume and tension, 108 to the minute; temperature per rectum 99.6; leucocytes 16,000. Urinary examination negative. The abdomen is somewhat distended, especially in the upper portion. Respiratory movements are somewhat limited. No loops of bowel and no peristalsis seen. There is some general abdominal tenderness, which is quite marked in the middle of the epigastrium, but there is no definite rigidity or muscle spasm and no mass can be felt.

*Operation.*—Incision was made through the upper portion of the right rectus muscle. The transverse colon immediately presented in the wound and seemed somewhat distended. The small intestine was not distended and there was no sign of intestinal obstruction. There was a small amount of fluid in the abdomen, but it was not blood stained. There were numerous adhesions about the gall-bladder, but no stones were felt in the gall-bladder or ducts. The pancreas was palpated and found to be twice its normal size and rather firm. Numerous fat necroses were found in the gastrohepatic omentum, gastrocolic omentum and transverse mesocolon. The pancreas was exposed through an opening in the gastrocolic omentum, a small incision was made in the pancreas and a gauze drain placed down to it. The gall-bladder was opened and found to contain a considerable amount of very dark bile. Cultures were made from the bile and proved to be negative. A cholecystostomy was performed. This case, which is the earliest and

most favorable case of acute pancreatitis which the writer has ever seen, made an uneventful recovery and was discharged from the hospital October 10, 1909.

**CASE IV.**—Mrs. W. M., aged thirty-six years, was admitted to the hospital April 14, 1911, complaining of pain in the abdomen radiating to the back. *Family history:* Unimportant. *Personal history:* Has had measles, mumps and whooping cough. Had typhoid fever ten years ago. Has suffered with stomach trouble for eight years, manifested by vomiting and pain in stomach radiating to the back. Has had nine children, youngest being one month old.

*Present Illness.*—Patient gave birth to a child four weeks ago. Before the birth of the child she suffered from burning, cramp-like pains in the stomach, passing to the right shoulder, and these pains have become worse and continued to the present time. They have required frequent hypodermics of morphia. Six days ago she vomited a large amount of bile-stained material. At that time she was jaundiced. She had chills every night for a week after the birth of the child.

*Examination.*—Patient is a thin woman, looks sick. Sclerotics are distinctly bile stained. Pulse is of fair quality, 92 to the minute; temperature 100 on admission; leucocytes 9,200. Coagulation time four minutes. Urine analysis negative. The abdomen is flat and slightly asymmetrical, there being a fulness in the right hypochondrium. On palpation there is considerable tenderness in the epigastrium and right hypochondrium. No mass can be felt in the epigastrium, but in the right upper quadrant the edge of the liver can be felt, 5 cm. below the costal margin, and beneath this a rounded body, the size of a hen's egg, which feels like a distended gall-bladder. On inspiration it descends almost to the level of the umbilicus.

*Operation.*—Incision was made through the upper portion of the right rectus muscle. The gall-bladder was found to be considerably distended and numerous stones could be felt in it. The gall-bladder was aspirated and a large amount of bile obtained, which would seem to indicate an obstruction of the common duct rather than of the cystic duct. The gall-bladder was then opened and numerous small, faceted stones and one stone the size of a walnut removed. A careful examination of the common duct failed to reveal any stone. The pancreas was examined and the whole organ found to be greatly enlarged and fairly fixed in position. In places the limits of the gland were not well defined. In the transverse mesocolon near the pancreas there were several areas of fat necroses, suggesting a subacute pancreatitis. A large rubber tube was sutured in the gall-bladder and the abdominal wound partly closed.

*Post-operative Course.*—The patient did fairly well for a few days after the operation, then began to run a temperature and the pulse became more rapid. She died rather suddenly nine days after the operation.

*Autopsy.*—About a litre of blood was found in the abdominal cavity. Mesentery of the ascending colon infiltrated with blood. Head of the pancreas converted into necrotic, hemorrhagic mass. Numerous

fat necroses found. The pancreatic ducts were patent but a firm calculus 5 mm. in diameter was found in the ampulla of Vater.

*CASE V.*—Mrs. T. G., aged twenty-six, was admitted to the hospital, February 15, 1914, complaining of abdominal pain and vomiting. *Family history:* Patient has had two children, youngest seven weeks old, labor and puerperium uncomplicated. Last summer, nine months ago, she had two mild attacks, suggesting gall-stones.

*Present Illness.*—Ten days before admission patient was taken with severe pain in the upper right abdomen, was nauseated and vomited. Pain seems to have been confined to the gall-bladder region, did not radiate to the back or right shoulder. Following the subsidence of acute suffering there remained soreness and tenderness in the upper right abdomen. The pain persisted with varying intensity. Five days ago jaundice was first noticed, but it has largely disappeared. Until two days ago she had been up a portion of each day and during that time had little if any temperature. Two days ago she was seized with agonizing pain in the upper right abdomen requiring three-quarters of a grain of morphia for partial relief. Nausea and vomiting became pronounced and have persisted to this time. Bowel movement was obtained by use of cathartics, stools being very light colored.

*Examination.*—Patient is a well-nourished woman, but looks septic and very sick. Sclerotics are slightly bile stained. Temperature on admission 103.6; pulse 134, of rather poor quality; leucocytes, 20,800. Urine analysis negative. Abdomen is quite distended, symmetrical, no mass seen. There is some general abdominal tenderness, but tenderness is much more marked in the epigastrium and right hypochondrium. There seems to be an indefinite resistance in the right side of the epigastrium, but no mass can be felt. Abdomen is everywhere tympanitic. Liver dulness reaches the costal margin in the nipple line. The patient was thought to have a gangrenous cholecystitis.

*Operation.*—Incision was made through the upper portion of the right rectus muscle. On opening the peritoneum a considerable amount of yellowish fluid escaped, and it was thought that the gall-bladder might have ruptured, but the gall-bladder was found in fairly good shape, though its walls were slightly thickened and it contained a number of small stones.

Further examination revealed numerous disseminated fat necroses distributed widely throughout the omentum and transverse mesocolon. A large mass was found in the region of the pancreas. The lesser peritoneum was opened and a considerable amount of chocolate-colored fluid evacuated. Incisions were made through the peritoneum covering the pancreas and a considerable amount of the same kind of fluid evacuated. The whole pancreas was thickened but it was not as soft as it often is in cases of acute pancreatitis. Small incisions were made into the pancreas and cigarette drains placed in these openings and in the peripancreatic tissues.

The gall-bladder was opened and about twenty small mulberry stones, 2 to 5 mm. in diameter, removed. The bile was very dark and somewhat thicker than normal. Rubber tube was sutured into the gall-bladder for drainage. Considering the character of the stones and

## ACUTE AND SUBACUTE PANCREATITIS

the fact that the patient gave a very definite history of a fairly intense jaundice a few days before admission, it was thought that one of these stones had at one time occluded the opening of the diverticulum and caused a retrojection of bile into the pancreas. This represents a fairly acute case of pancreatitis.

*Post-operative Course.*—Convalescence was very tedious. Temperature remained somewhat elevated for several weeks. About eighteen days after operation patient became nauseated and vomited without ascertainable cause. From this time until her discharge she had vomiting attacks, sometimes daily, at others at intervals of two to six days. Aside from this feature the last two months of her stay in the hospital were passed in remarkable comfort. The fistula discharged freely for some time, large pieces of necrotic tissue (pancreas) coming away at times. The skin about the fistula was considerably excoriated by the pancreatic discharges. The patient remained in the hospital eighty-one days after the operation and was still quite weak when she left, but I learn from her doctor that she is now perfectly well.

CASE VI.—Mrs. J. A. H., aged forty-eight, entered the hospital February 17, 1916, complaining of stomach trouble. *Family history:* Unimportant. *Personal history:* Has never had typhoid fever. Had pneumonia nineteen years ago. Has suffered with "indigestion" for years. Has had four children, no complications during labor or puerperiums.

*Present Illness.*—About a year ago she had a severe attack of epigastric cramp, mainly upon the *left* side. Pain was intense, lasted about six hours. Since then she has at irregular intervals had similar attacks, sometimes with vomiting, sometimes without. There has been little if any temperature. Preponderance of pain has been in the left epigastrium, some, however, in the upper right abdomen with occasional radiation to the back. She has never vomited blood. Her last attack, which was very severe, occurred the day before admission and lasted about six hours.

*Examination.*—Patient is moderately nourished, appears rather weak. Sclerotics distinctly jaundiced. Temperature 100; pulse 100, fair volume and tension. Urine examination shows a trace of albumen, no sugar. Abdomen is flat. No visible masses. There is tenderness across the whole upper abdomen, especially in the midepigastrium and a few inches to the left. No masses felt. Liver dulness reaches the costal margin in the right nipple line. A diagnosis of gall-stones was made.

*Operation* (April 20, 1916).—A high right rectus incision. On opening the peritoneal cavity no free fluid was noted. The gall-bladder was found to be somewhat thickened and to contain gall-stones. Numerous fat necroses were found in the omentum and peritoneal fat. The pancreas here was markedly thickened and firm throughout. No stones could be made out in the common duct. One large and several small, mulberry stones were removed from the gall-bladder and cholecystostomy done. The pancreas was not drained.

This seems to be an example of an acute exacerbation of a chronic pancreatitis.

*Post-operative Course.*—Patient had an uneventful convalescence. Wound healed nicely. General condition good at time of discharge, four weeks after operation.

CASE VII.—Mrs. J. H. H., aged forty-eight, was admitted to the hospital April 8, 1916, complaining of pain in the stomach. *Family history:* Unimportant. *Personal history:* Patient has been having attacks similar to the present one for the last five or six years, coming on at intervals of several months and often lasting for several days, but none has been as severe as this one. No history of previous jaundice, chills or fever. Bowels somewhat constipated and stools of yellow color. No urinary disturbance. She is the mother of eight children.

*Present Illness.*—About ten days before admission patient was seized with severe cramp-like pain in the epigastrium, radiating to the back, more to the left and also down into the lower abdomen. She suffered much pain and vomited almost continually for a number of days. Pain has been almost constantly present since onset. Says she has been very tender in upper abdomen.

*Examination.*—Patient is a rather stout woman. General condition seems fairly good. Skin is slightly yellow and sclerotics are definitely bile stained. Temperature 101; pulse 90, of good quality; leucocytes 15,000. Urine analysis negative. Abdomen is not distended. There is considerable tenderness in the gall-bladder region and as far down as the appendix region. There is some tenderness in the epigastrium and to the left. No masses felt. Liver and gall-bladder not felt. No dulness.

*Operation* (April 10, 1916).—High right rectus incision. No free fluid in peritoneal cavity. The omentum was found adherent to the gall-bladder and showed numerous patches of fat necrosis. The gall-bladder was moderately distended and contained one large stone without facets. There was considerable induration around the common duct, but no stones could be felt in it. The pancreas was much thickened and indurated throughout its extent. A rubber tube was sutured into the gall-bladder and iodoform gauze packed around the gall-bladder and toward the foramen of Winslow.

*Post-operative Course.*—Patient did fairly well for four or five days after operation. She then became more deeply jaundiced, began vomiting. Wound broke down throughout and discharged bile and a thin brownish fluid. Vomiting became persistent. Pulse became rapid and weak. Temperature which had been elevated since admission gradually rose and during the last days ranged between 104 and 106. She died sixteen days after the operation.

*Autopsy.*—A post-mortem examination was made and revealed a subdiaphragmatic abscess, extensive fat necroses in the great omentum, mesentery, subperitoneal fat and about the liver and right kidney. The pancreas was adherent and was dissected out with difficulty. Its head was entirely necrotic, leaving nothing but a blackish debris. Its body and tail were intact, but quite hard and showed nothing unusual on section. Pancreatic duct necrotic and could not be found. No obstruction found in the common duct.



## ACCESSORY PANCREAS WITH INTUSSUSCEPTION

BY ARTHUR E. BENJAMIN, M.D.

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IN "Diseases of the Stomach and Intestines," R. C. Kemp states that "Accessory pancreas is a mass of pancreatic tissue entirely separate and having its own duct; may assume the function of the main organ when diseased and may cause diverticula or herniæ of the wall of the intestines."

Opie reports 10 cases in 1800 autopsies, dividing them into two groups, viz., those lying above the pancreas in the duodenum and stomach and those in the duodenum and jejunum.

Accessory pancreas has also been found in the ileum, in an umbilical fistula, in mesentery of duodenum and in fat of great omentum. The aberrant pancreas averages 1 cm. in diameter though it has been 4.5 cm. More than one may be found in the same person. About one-third of these glands are situated in the wall of the stomach in the submucosa near the pylorus and about two-thirds occur in the intestinal wall and more frequent in the muscular layer. The tissue of an aberrant gland is not different from normal pancreas in histologic features. The pathological changes affecting accessory pancreatic tissue are fat necrosis, chronic interstitial inflammation and malignant growth.

A number of cases are recorded in which accessory pancreas is associated with diverticulum of intestines occurring in the jejunum, ileum, duodenum and once even in the stomach side. A diverticulum usually occurs in children from less than a year to fourteen years of age. "The results of these diverticulæ are intestinal obstruction, acute intraperitoneal inflammation, hernia into the pancreas with or without hemorrhagic necrosis."

Dr. G. F. Ruediger states in the *Journal of the American Medical Association*, 1903, that accessory pancreas may sometimes be a causative factor in the production of diverticulum of the intestine by exerting continuous traction on the intestinal wall, during development; or it may at any time become the starting point of a carcinoma. This has, however, never been observed. If the swelling protrudes into the lumen of the bowel and attains a considerable size, it might produce some obstruction to the movement of the intestinal contents, or perhaps it might cause an intussusception by continuous traction on the inner surface of the intestinal wall, from the passage of the contents over it.

Dr. Aldred S. Warthin reported in the *Physician and Surgeon*, 1904, page 338, the following statistics of the location of accessory pancreas: Wall of stomach, 14; wall of duodenum, 12; wall of jejunum, 15; wall of ileum, 1; wall of intestine, 1 (not definite); diverticulum of stomach, 1; diverticulum of jejunum, 1; diverticulum of ileum, 4; Meckel's diverticulum, 1; umbilical fistula, 1; mesenteric fat, 1; omentum, 1; 53 (49 cases).

CASES REPORTED IN JEJUNUM

- 1 (1859).—Reported by Klob: location, posterior wall of jejunum. Numerous small ducts. No excretory duct.
- 2 (1860).—Reported by Montgomery: location, upper part of jejunum beneath the serosa, one inch in diameter. Microscopical structure, identical with that of pancreas, no duct.
- 3 (1861).—Reported by Zenker: location, first coil of jejunum close to the duodenum. Microscopical structure, identical with that of pancreas. Excretory duct opening into intestine.
- 4 (1861).—Reported by Zenker: location, first coil of jejunum close to duodenum. Microscopical structure, identical with that of pancreas. Excretory duct opening into intestine.
- 5 (1861).—Reported by Zenker: location, first coil of jejunum 16 centimetres from duodenum. Microscopical structure, same as that of pancreas. Excretory duct opening into intestine.
- 6 (1861).—Reported by Zenker: location, two accessory glands, one 16 centimetres, the other 48 centimetres from duodenojejunal junction. Both in submucosa. Microscopical structure identical with that of pancreas. Excretory duct opening into intestine.
- 7 (1896).—Reported by Hanseman: location, in tip of diverticulum of upper portion of jejunum. Not described.
- 8 (1900).—Reported by Nicholis: location, in wall of beginning jejunum. Projecting into lumen. Microscopical structure, multiple lobules. Small excretory duct.
- 9 (1903).—Reported by Opie: location, in submucosa of jejunum, 11 centimetres below duodenum, opposite the mesentery. Pancreatic tissue in bile papilla. Microscopical structure resembles an adenoma. Contains centro-acinar cells. Interstitial inflammation. Islands not mentioned. Tubular structures resembling ducts. Excretory duct not determined.
- 10 (1903).—Reported by Opie: location, in submucosa of jejunum, four metres from duodenum. Microscopical structure, ducts resembling those of pancreas. No acini, dense fibrous stroma. Excretory duct not determined.
- 11 (1903).—Reported by Ruediger: location, in muscular coat of wall of jejunum, 15 centimetres from duodenojejunal junction. Microscopical structure identical with normal pancreas. Numerous small ducts. Typical islands of Langerhans. Large duct opening into intestine not positively demonstrated.
- 12 (1903).—Reported by Thorel: location, mass 2.8 centimetres long, thickness of the little finger, in wall of middle of jejunum. Marked prominence on both mucous and serous surfaces. Microscopical structure: made up chiefly of complicated system of ducts lined by columnar cells. Pancreatic acini, but no islands of Langerhans. Excretory duct followed to mucosa. Opening not determined.
- 13 (1903).—Reported by Thorel: location, middle of jejunum. Partly covered by atrophic mucosa, somewhat smaller than a pea. Microscopical structure of an adenomyoma. No pancreatic parenchyma. Three excretory ducts.
- 14 (1903).—Reported by Thorel: location, middle of jejunum. Partly covered by atrophic mucosa. Somewhat smaller than a pea. Microscopical structure of an adenomyoma. No pancreatic parenchyma. One excretory duct.
- 15 (1903).—Reported by Thorel: location, two accessory nodules of pancreatic tissue, one in the wall at upper third of jejunum, the second about three finger breadths from this, embedded in the mesenteric fat. The intestinal one 3.2 centimetres long by 1.2–1.8 centimetres in diameter; the mesenteric the size of a two-mark piece and 1 centimetre thick. Microscopical structure; between circular and longitudinal muscle coats. Both identical with normal pancreas. Numerous islands of Langerhans. No excretory ducts found in either nodule.

## ACCESSORY PANCREAS WITH INTUSSUSCEPTION

16 (1913).—Reported by Short: Causing acute pancreatitis and excited acute inflammation of the muscular coat of the surrounding jejunum producing considerable obstruction, incessant vomiting, slimy diarrhoea and melæna.

17 (1908).—Reported by T. Carwardine: In all of jejunum, two inches from duodenojejunal flexure, about size of filbert.

*Personal Case* (BENJAMIN).—White, German, 39 years of age; farmer last three years, blacksmith previous to that time. Best weight, 171 pounds; average weight, 160 pounds. Weight three weeks ago, 120 pounds, still losing. Loss of weight has been constant since January 20 last (three months ago).

*Family History*.—One sister died of T. B. (pulmonary) 18 years ago. No familial disease.

*Past Illnesses and Injuries*.—Kicked by a horse fifteen years ago in the thigh, a tumor the size of a hen's egg from this region was removed thirteen years ago. Pneumonia twice, last time six years ago, no complications. Four years ago had some cough during winter, expectorated blood, not laid up. Last winter (in early part) had mild cough and expectorated considerable blood. Blood was bright and frothy. Not laid up from work.

*Present Illness*: Fifteenth of January, 1917, began having difficulty in passing urine. Had to urinate six or seven times during the night, very small amount at a time. No blood; at the same time began having severe pain in the lower part of abdomen which extended over into left side, at times pains were sharp and "stitchy" and lasted a couple of minutes. No particular relation to urination. Since then (for the last two months) pain has been located in upper right quadrant, of different character than that which began in January, being heavy and "grinding and very weakening." Starts in upper right side and moves over to region of umbilicus. Had "rolling, bubbling" sensation in right side which seemed to have moved toward stomach.

For the last two months has had vomiting spells, for first month spells occurred once a week, but of late the spells have increased in frequency to every two or three days. Emesis has always been very large in amount (1-2 quarts). Dark green and bitter. No blood nor undigested food particles. Taking of food never distressed him, nor have they had any relation to the vomiting spells.

Vomiting attacks came on without pain or effort, "simply flowed out," as patient said. Attacks occurred night or day and without warning, they always seemed to relieve pain in the right side.

Stools never constipated. Began to be black January 15, 1917, at time that his present illness commenced. Stools black for last three months, with exception of last three weeks when they have had their natural color. Never had nose bleed nor bleeding from gums. First of the year patient noticed that he tired more easily and legs felt weak. Tired feeling became progressively worse and during last two months has been very weak. Noticed that his skin began to get very pale the last of January. Feet never became swollen, never swollen under eyes, never bloated.

For last week has been expectorating considerable muco-purulent material.

*Laboratory Findings.*—Urine, normal. Blood, hæmoglobin 50 per cent.; leucocyte count, 11,000. Gastric analysis, Ewald test meal, aspirated in one hour. Amounts, 250 c.c. yellow, some brown and coarse particles, mixed with mucus, sour odor, bile tinged. Free HCl, 10. Total acid, 40°. Lactic acid, trace. Blood, trace. Microscopically, nothing of importance.

Sputum showed no *B. tuberculosis*, pneumococcus predominant. Essential points in fluoroscopic examination of stomach: showed marked hyperistalsis, with occasional spastic contractions, pylorus open, duodenal cap not distinct.

Each pyloric contraction was immediately followed by a marked bulbous dilatation of the third or horizontal portion of the duodenum (dilatation attained the size of the stomach, presenting a very impressive appearance).

*Sixth Hour Examination.*—Some residue in stomach, marked dilatation of the duodenum as above. Patient was allowed to eat at this time by mistake.

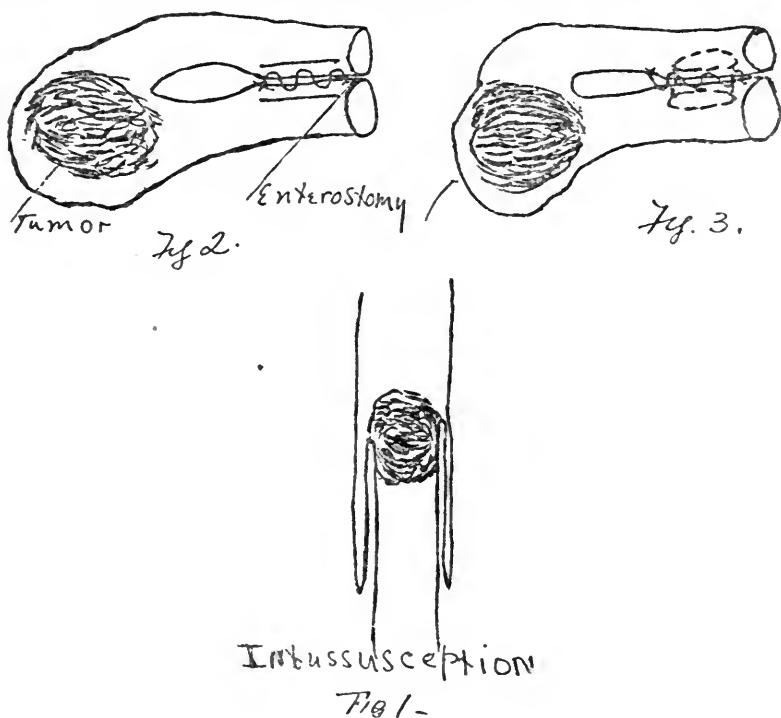
*Ninth Hour Examination.*—Small intestine empty. Tenderness over hepatic flexure, appendix visible, cæcum free.

An exploratory operation was performed at the St. Barnabas Hospital April 21, 1917, the patient taking about 3½ oz. of ether. The operation was begun at 9.50 A.M. A median incision was made above the umbilicus. No gall-stones were found, the pylorus was patulous, but there were adhesions extending across the pylorus and pyloric end of the stomach. There were some signs of perigastritis. The cæcum was dilated, the appendix normal. The mesentery of the ascending and transverse colon brings these sections closely together. The sigmoid was redundant but not dilated. There was an intussusception of the upper part of the jejunum beginning about eight inches from the ligament of Treitz involving about a foot and a half of the jejunum. This was reduced and found to contain a tumor-like mass involving the jejunum about 10 inches from the ligament of Treitz, this tumor-mass being about  $2 \times 1\frac{1}{2} \times 1$  inch with inverted portion of bowel and one inch square ulceration of the serosa (see Figs. 1, 2, and 3). This ulceration may have been due to interference with the circulation on account of the intussusception. It was thought best not to remove the growth, owing to the obstruction at this point and the weakness of the patient, but a side-to-side anastomosis was made of the jejunum above and below this mass, the portion below being much dilated, having enveloped the tumor-mass by creeping upward and around it. The anastomosis was made with linen (Pagenstecher) 2 rows loosely drawn, on account of the friability of the tissue about the tumor; these sutures were supplemented by fine chromic catgut outside. The omentum was stitched down on to and over the line of sutures and a tube put down to it for drainage. The stomach wall was somewhat fibrous. The peritoneum was closed with plain catgut No. 2 double chromic double No. 1 for fascia and the skin with chromic No. 1 single. The operation was completed at 10.55 A.M. Pulse before operation, 90; pulse during operation, 90–128–124; pulse after operation, 100. Blood-pressure under anæsthesia before operation, 128; blood-pressure under anæsthesia after operation, 100.

## ACCESSORY PANCREAS WITH INTUSSUSCEPTION

A hypodermic of morphine, gr.  $\frac{1}{6}$ , with atropine, gr.  $\frac{1}{150}$ , was given at 8.30 A.M. before the operation.

April 25, 1917: Has been vomiting some since operation, pulse very weak, stomach washed, vomiting ceased, pulse continued rapid. Bowels loose, unable to retain saline solution. Investigation of wound showed an opening below the tube with a separation of the skin and muscle tissue but scarcely any discharge. Further investigation found the peritoneum and muscle layer had separated completely owing to defective suture or rapid absorption, more likely the former. The wound was immediately stitched under local anæsthesia with interrupted silkworm-gut sutures extending through the skin, muscle and



peritoneum, crossed and tied over rubber tubing. About eleven sutures were used in all. Very little pain was experienced, a hypodermic being previously given. The patient felt better after the closure of the abdomen. The intestines looked healthy, not distended but somewhat adherent around the wound.

Patient did fairly well for a few hours but died April 26, 1917, probably due to inanition and shock, not having had any nourishment to speak of for three or four weeks, as he had vomited and had become greatly emaciated.

The tumor which was removed was  $3 \times 4 \times 3$  cm. A cauliflower-like mass projects from the mucous membrane by a stem a short distance from the duodenojejunal junction. The pulling by the stem of

the intestinal wall together with the growth causes a partial obstruction and an initial step of the intussusception. The tumor-mass is hard and friable and appears typically carcinomatous (Fig. 4).

Microscopic sections show mucous membrane intact except for slight inflammatory changes and occasional infiltration of the tumor cells. The compact mass of tumor cells arranged within alveolar mesh work is primarily located in the submucosa with occasional areas of downward infiltration into muscularis.

Cells uniform in size with no mitosis are granular, giving the appearance of its secretory nature. There are found no secretory ducts, no areas corresponding to those of Langerhans. The structural appearance microscopically, otherwise, is that of pancreas.

*Diagnosis.*—*Adenoma of accessory pancreas.* The question of malignancy is still disputed, mainly because of the evidence of downward infiltration into muscularis.

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FIG. 4.—Tumor caused by degenerated accessory pancreas.





## SPLENECTOMY IN SPLENOMEGALIES\*

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FOR no other of the viscera as for the spleen has the minute study of the functional co-relation of that organ to the remainder of the bodily economy brought so many practical surgical applications.

Accomplished for the first time by an Italian surgeon, Zaccarello, in 1549, for a malarial splenomegaly (so says Fioravanti in his *Tesoro della vita Humana*), splenectomy had been reserved over a long period of years for cases of hernia of the spleen through parietal abdominal wounds (cases reported by Viard, Mathias and others). And from this date, we must pass to 1826 before finding that a diseased condition of the spleen incited surgical intervention and removal of that organ (Quittenbaum's case). This concept led to the splenectomy undertaken by Kuchler (1855) and Spencer Wells (1865) with, however, fatal issue. It would appear from the literature that the merit of having first accomplished a successful splenectomy belongs to Pean (1867), who, it is said, also established the fundamental rules governing surgical intervention in cases of splenomegaly. From this time on it gradually became more and more the current practice to extirpate the spleen in strictly surgical conditions, such as neoplasia and animal parasitic accumulations. Finally, when pathological research upon the hæmopoietic apparatus and the glands of internal and external secretions accentuated the value of the splenic factor in a number of abnormal conditions of the blood and glandular systems, numerous lesions of the spleen which had been theretofore characterized as dominantly medical considerations were pronounced surgical conditions; and thus Vulpius (1893) reports upon 121 splenectomies; Bessel-Hagen (1900), 218 splenectomies; Johnston (1908), 708 splenectomies.

Splenomegaly is a clear concept; it deals with an inherent increase in the volume of the spleen exclusive of certain pathological entities, such as abscesses, parasitic cysts and tumefactions incident to acute infective proc-

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\* In March, 1916, it was my privilege to assist at a splenectomy done by Dr. Paul Pilcher, who then asked me to gather whatever literature I could relative to the prognosis of splenectomy in splenomegalies, with the view of making a chemical survey of the blood to determine, if possible, what relation the spleen bore to the etiological pathogenesis of certain forms of essential anæmias. I have only recently completed a collection of American and Continental monographs bearing on this subject, the delay having been occasioned by faulty delivery of transatlantic correspondence incident to the war. I now offer my manuscript for publication in the ANNALS OF SURGERY, in memory of Dr. Paul M. Pilcher, whose keen insight into matters pathological has awakened in me a new vision of the field of pathology, and has inspired me to new inquiries along this most fruitful line.

esses, and lastly, those chronic intoxications and circulatory disturbances which occasion "amyloid" spleen and "cardiac" spleen (Banti). Splenomegaly deals with: (1) Infantile splenomegalic anæmia; (2) Griesinger type splenic anæmia; (3) Banti's disease; (4) Vaquez's disease; (5) Gaucher type splenic anæmia; (6) chronic splenomegalic hæmolytic jaundice; (7) leukæmia and pseudoleukæmia; (8) pernicious splenomegalic anæmia.

To these may be added the splenomegalies incident to: (9) Primary tuberculosis of the spleen; (10) splenic syphilis; (11) malarial spleen; (12) infection with Leishmann's spirillum.

*Infantile Splenomegalic Anæmia.*—Omitting a discussion of the histopathology and minute clinical manifestations of this disease, it suffices to record here as infantile splenomegalic anæmia, studied by Cardarelli, Fede, von Jaksch, Luget, Sternberg, Mya and others, that progressive anæmia found among children which terminates fatally usually before the first year, seldom reaching the second year of life, and has its course characterized by a considerable enlargement of the spleen. Bearing in mind that the spleen exerts a hæmapoietic function, but also a hæmocatatonic, if not an actual hæmolytic activity, the conception of treating the disease surgically by splenic extirpation was early entertained. DeRenzi induced *Salvia* so to intervene and reported eminent success in one case. Buren, Knott and Beccherle were equally successful. Wolff and Graff, however, were unsuccessful in that the complete clinical syndrome returned one year following removal of the spleen in the case reported by them.

It would seem advisable to follow the recommendation of DeRenzi in this condition, more especially when we consider how futile is recourse to therapy in this disease (iron, arsenic, antiluetic treatment, etc.).

*Griesinger Type Splenic Anæmia.*—Gretzel in Griesinger's clinic at Berlin (1868) proposed the term splenic anæmia in describing the case of a child who on examination was found to have quite a large spleen attended with some enlargement of the liver and lymph-nodes, though examination of the blood showed the absence of leukæmia. Krumbhaar wisely indicates that a term like "splenic anæmia," which we now believe to include several distinct types, should properly be restricted or discarded entirely; and, while accepting Krumbhaar's opinion, the fact is reported that Banti invited Colzi to perform a splenectomy upon a case diagnosed splenic anæmia, the result, however, being lost to literature.

*Banti's Disease.*—It would seem that the results of splenectomy show to their best advantage when surgery is practised in Banti's disease before hepatic cirrhosis has developed (second period) or ascites begun (third period); in other words, during the first period when only anæmia and splenic enlargement exist. Banti holds that the causative agent, perhaps infective, is first localized to the spleen where splenotoxins are elaborated and from whence they circulate, giving rise to anæmia and cirrhosis of the liver—a chronic interstitial hepatitis of splenic origin—just as alcohol occasions a chronic hepatitis, though of gastro-intestinal origin. The enlarged

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spleen does not appear to show anything especially distinctive beyond a general fibrosis and a marked adenoid structure, the so-called "*fibroadenie*" of the French.

In the first period, extirpation of the spleen including the toxic *locus* is followed by prompt and complete cure (Banti). In fact, whereas cases of splenomegaly due to Banti's disease terminate fatally when consigned to medical care alone, in those cases operated upon by Colzi at Banti's request the report showed 100 per cent. recovery in two cases during the first period; 66 $\frac{2}{3}$  per cent. recovery in three cases during the second period; and death in one case during the third period. In a second series including 11 cases, Banti reports about the same proportion of recovery to the period of the disease. The following statistics would confirm Banti's view:

Reported by	Year	Cases	Deaths	Per cent. mortality
Bessel-Hagen.....	1900	16	3	18 $\frac{3}{4}$
Armstrong.....	1907	32	9	28
Torrance.....	1908	36	10	28
Johnston.....	1908	61	12	19 $\frac{1}{2}$
Muhsam.....	1914	29	5	17
Criscenzi-Rossi.....	1915	15	4	26 $\frac{2}{3}$

Bret and Cordier (1911) summarize their findings as follows: Mortality in first period operations, 25 per cent. Mortality in second period operations, 40 per cent. Mortality in third period operations, 60 per cent. It is noteworthy to add the experience of Roch who, of 13 cases of Banti's disease wherein a splenectomy was done, the cases having progressed to the third period and marked by pronounced hepatic cirrhosis, reported but 4 deaths; and these figures agree with the favorable reports of Quenn, Duval, Humber, Berard, Zancan and Thial. Carre, Jaffe, Levison and Thole all report success following splenectomy in Banti's disease and strongly advocate surgical intervention.

*Vaquez's Disease.*—This most rare affection which had been described before Vaquez by Widal and Render is characterized by its threefold symptomatology, splenomegaly, anæmia and cyanosis. Its pathogenesis is the subject of much discussion and uncertainty. Equally uncertain is the therapy. Schneider, Cominotti and Jedlick endeavored in vain to secure a remedy through the practice of splenectomy, but they all three reported complete failure. It is being more and more conceded that this type of splenomegaly is not a distinct entity, but belongs to one of the other described types of splenic anæmia.

*Gaucher's Disease.*—Whether this form of anæmia with splenic involvement is to be considered a true splenic tumor (endothelioma) or a generalized hematopathy with splenic localization, still remains a matter of dispute. Gaucher spoke of a splenic epitheliomatous condition, which conception was shared by Picon and Rammond. Then it was noticed that the pathology involved either the endothelial elements of the spleen (Bovaird) or the

supporting parenchymal interstitial tissue (Schlangenhaufer). Other observers soon reported that the condition was not indigenous to the spleen but is met in the liver, certain groups of lymphatic glands, and in the osseous marrow (Brill, Marchand, Mandlebaum, Knox, Whol, Hermann). If the latter pathology were correct, it would seem that splenectomy were contraindicated. Yet Chavannez and Gujot report 4 cases of the Gaucher type anæmia where splenectomy was done and a cure obtained. Giffin reports three cases with three cures, but it is doubtful if two of the cases reported are typically of the Gaucher type splenomegaly. Contrary to the teachings of the surgeon Silvestrini, one should feel no hesitancy in performing a splenectomy in this type of anæmia.

*Chronic Splenomegalic Hæmolytic Icterus.*—Two types of this form of hæmolytic jaundice are recognized: (1) The congenital type of Minkowski-Chauffard; (2) the acquired type of Hayem-Widal. Thayer groups both types under the heading hæmolytic jaundice, and Tillston under the heading chronic family jaundice. Krumbhaar, following the continental custom, favors the distinction into two groups; and since both types are quite characteristic and distinctly pronounced, the dual classification should be retained.

It was held for considerable time that the origin of these hæmolytic icteric forms of splenomegaly was inherent in the liver, more precisely, in the particular functional and congenital alteration of the hepatic cell (Pick), or, infective angiocholitis (Loevy, Hayem and Strauss) favored, according to Gilbert, by a morbid hereditary predisposition of the biliary canals. At this time, however, Widal, Marchiafava and Nazzari claim that the fundamental pathology of the conditions lies in a lesion of the blood which is both chronic and destructive. The fact remains that in the splenectomies reported by Bland-Sutton, Colzi, Micheli, Oliva, Fiori, Bastanielli, Ranzi and others, and including both classifications of hæmolytic jaundice, 5 deaths in 48 cases followed.

*Leukæmia and Pseudoleukæmia.*—It is not certain to what extent the existing theories relative to the pathogenesis of the leukæmias have occasioned the surgical therapy of splenectomy in these morbid conditions. Whether one adheres to the neoplastic theory of Bard and of Banti, or to the theories of Ehrlich or Neumann, it is generally conceded that the entire hæmatolymphopoietic system participates in the various lymphoid, myeloid and cellularplastic transformations that characterize the various forms of leukæmia and pseudoleukæmia (comprising the splenomegaly with myelocytæmia of Weil and Clerc and the myeloid splenic anæmia of Vaquez and Anbertin). Certain it is that in the pathology of these morbid processes, the spleen does not occupy either an exclusive or predominating rôle; and the extirpation of that organ has not been recorded as benefiting the disease.

This view is borne out by the surgical experiences of Vulpius, who in 28 cases of splenectomy in leukæmic enlargement of the spleen had 25 deaths; Bardenheuer, in three cases had three deaths; Franzolini reported a complete cure, but strict scrutiny of the history of the case would indi-

cate that the disease was a Banti's splenomegaly, not a leukæmia of any sort; Vanvers had 26 deaths in 29 cases; Bisset-Agen, in a series of 42 cases of splenectomies for leukæmic tumefaction of the spleen, had only 4 recoveries, of which 2 ultimately died of the primary leukæmic involvement. The statistics of Legnani show 5 deaths in 6 cases; those of Johnston, 43 deaths in 49 cases. Giffin reports one case in which the diagnosis was not certain; the patient remained well for five and one-half years, after which time the leucocyte count increased to 64,000, with 14 per cent. myelocytes.

Some success was reported by Hartmann, Penginez and Julien, Kuttner and Pimentel. For about an average of three years following splenectomy, these observers reported beneficent results; but at the end of that time, a cachexia develops which runs to a rapidly fatal end.

In general, splenectomy is not followed by favorable results in splenomegalic conditions incident to leukæmia or pseudoleukæmia.

*Pernicious Splenomegalic Anæmia.*—Some cases of so-called pernicious anæmia develop an extreme tumefaction of the spleen. This led Empiger to believe that the spleen was the seat of an exaggerated pathological destruction of red cells, and he, Empiger, having had considerable good fortune with splenectomy in cases of hæmolytic jaundice, conceived splenectomy as a measure to be adopted in this form of anæmia; and in 1913, together with Exner, Empiger communicated successful splenectomies in cases of pernicious anæmia.

Just previous to this time Banti had recommended splenectomy in cases of progressive pernicious anæmia. In short order surgical literature was enriched with reports of new cases wherein splenectomy was followed by tolerably favorable results. Huber, Mosse, Hirschfeld, Klemperer, DeCastello and Hassing reported favorably; and at the Forty-third German Congress of Surgery (1914) Mühsam exhibited 15 cases of pernicious anæmia with performed splenectomies and gave evidence of the good results attending such procedure. Shortly after this demonstration, however, quite unsatisfactory reports accumulated, whether through an inherent inefficacy on the part of splenectomy to aid in correcting the pathology of pernicious anæmia, or from the innumerable complications like œdema, cardiac and pulmonary disturbances, hemorrhages, to which sufferers of pernicious anæmia are peculiarly prone.

Our present knowledge would direct a splenectomy in those cases only where a distinct splenomegaly evidenced by a marked tumefaction of that organ exists, and even in these cases, only illusive hopes as to recovery should be entertained.

*Tuberculosis and Incident Splenomegaly.*—In tubercular processes miliary or nodular involvement of the spleen occurs. More often this is secondary to an initial tubercular lesion elsewhere situated; but rarely, primary affection of the spleen has been recorded. In 1900 Bessel-Hagen reported three cases of clinical cure following an extirpation of primary tuberculosis of the spleen; and in 1901, Carle removed an enlarged spleen,

thinking the case to be one of Banti's disease, but found it a primary tuberculosis of the spleen. The patient, a female, recovered completely and shortly afterward gave birth to two children.

Laspeyres (1904) reports 2 cases analogous to that of Carle. Bayer in the same year reports 9 cases with 7 recoveries; Johnston (1908) reports 6 cases with 3 recoveries; Francke records 10 splenectomies for primary tuberculosis of the spleen with 7 complete recoveries; Fischer (1909), 12 cases with 8 recoveries; recently Michelsson reports 25 per cent. mortality in his series of cases.

*Syphilitic Splenomegaly.*—It has been comparatively well established that splenic tumefaction with diffuse interstitial sclerosis and endo- and epi-vascular lesions (Paris and Salmon) may be the only manifestation of hereditary syphilis (Fournier), and as the result of which there may be derived a symptomatology clinically and anatomically similar to that of Banti's disease (Michelli, Marchand, Hoke and Chiari); only two such cases wherein a splenectomy was performed have been recorded (Mansuso, 1888, Zuaccaro, 1901). Both were followed by favorable issue. Giffin reports that removal of the spleen in non-gummatous splenomegaly associated with syphilis has been attended with excellent results in two cases.

Doubtless such intervention should be adopted only after the most drastic antisyphilitic therapy fails.

*Malarial Spleen.*—As was indicated, splenic hypertrophy and hyperplasia owing to malaria was the first incentive for surgical intervention (Zaccarello). This precedent has remained.

In the spleen in preference to any other organ, the red blood-cells harboring the plasmodium are destroyed and the parasites liberated. These accumulate in the splenic lacunæ and give out their products of metabolism. The liver, independent of a primary malarial infectious localization, and intimately related in its blood supply with the spleen, suffers from the action of the malarial parasites collected in the spleen, (1) from the parasites that are able to issue alive from the splenic nest; (2) from the products of metabolism elaborated by the parasites in the splenic lacunæ; and (3) from the toxic action of the destroyed protein of the hæmolyzed red blood-cells gathered in the spleen.

The pathological effects of these circumstances upon the liver are obvious and formed the basis of the reason for splenectomy in malaria. Agreement between pathological reasoning and surgical practice, however, has not always been too perfect. Some operators have been highly successful, others highly disappointed with the outcome of the measure. The following statistics are worth consideration in this regard:

	Cases	Deaths	Mortality Per cent.
Bessel-Hagen .....	15	1	6.6
Vanverts .....	29	1	3.45
Papaionnon .....	12	1	8.33
Leonte .....	10	0	0

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*Splenomegaly Owing to Other Parasitic Infection.*—It is difficult to collect any authoritative reports relative to splenectomy in splenomegaly incident to kala-azar. Ill success has been reported; but whether other than splenic involvement existed does not appear.

In summary splenectomy would appear to be indicated in:

1. Banti's disease, first stages particularly.
2. Griesinger disease.
3. Minkowski-Chauffard and Hayem-Widal jaundice.
4. Primary splenic tuberculosis.
5. Hereditary splenic syphilis (after medication fails).
6. Chronic malaria attended with splenomegaly.

Splenectomy is of questionable benefit in:

7. Splenic infantile anæmia.
8. Pernicious splenomegalic anæmia.
9. Gaucher's disease.

It is contra-indicated in:

10. Splenomegaly incident to leukæmia and pseudoleukæmia.
11. Splenomegaly of kala-azar.

## INFLAMMATORY TUMORS OF THE ABDOMEN

BY PATRICK I. NIXON, M.D.

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ON December 10, 1914, there was brought to me a woman, K. G., aged nineteen, complaining of pain and a lump in the abdomen. Her general health prior to her present illness had been uniformly good. Her past history was unimportant aside from the fact that she had given birth to a normal child six months previously, and had passed an uneventful puerperium. Six weeks before she was seen she had right-sided abdominal pain of a colicky nature which subsided in two or three days; at this time a diagnosis of appendicitis was made by the attending physician. Two weeks later dull pain developed in the left lower abdomen, when for the first time the patient discovered a lump. These two complaints—dull pain and a lump—have been the two outstanding features. The patient thinks the lump has increased a little since it was first noticed. There has been no fever so far as can be ascertained. No symptoms referable to the bladder or intestines could be elicited. There has been a loss of about ten pounds in weight.

Physical examination revealed a rather under-nourished and anæmic woman. The general examination was negative except for the findings in the left side of the abdomen. On inspection, one saw in the left iliac fossa, a fulness, which on palpation proved to be a mass. This extended upward three cm. above the umbilical level and downward to within three cm. of Poupart's ligament; it reached the midline to the right and slightly into the flank posteriorly. The mass was only slightly tender to the touch, its consistency quite hard, and its surface somewhat irregular. No fluctuation was elicited. It was almost immovable and gave one the impression of being in the abdominal wall or at least densely adherent to it. Dulness on percussion was present over the involved area. The mass was not palpable through the pelvis and the pelvic organs seemed uninvolved.

The temperature and pulse during two days of observation were normal. The urine was normal. Wassermann reaction was negative.

In the face of these findings we were at a loss to explain the underlying condition and subsequent events proved that a correct pre-operative diagnosis would have been very difficult. Abscess arising from a left-sided appendix or diverticulum, adherent ovarian cyst, sarcoma of the ovary, tumor of the abdominal wall, tumor of the sigmoid or retroperitoneal structures, and localized tuberculosis were some of the possibilities that were considered.

Exploratory incision was made through the left rectus muscle over the most prominent part of the mass. When the sheath of the muscle was opened, the muscle fibres were found to be infiltrated and to a great extent replaced by a firm, homogeneous tissue. No peritoneal membrane could be demonstrated. Just beneath the muscle and densely ad-



## INFLAMMATORY TUMORS OF THE ABDOMEN

herent to it was encountered a very hard, non-fluctuant mass about the size of a small grape-fruit. This was looked upon as a new growth, and an attempt was made to remove it along with the overlying muscle. The peritoneal cavity was entered above and below the tumor. A good exposure revealed the omentum and several loops of small intestine intimately adherent to it. The sigmoid passed directly into the tumor mass. The adhesions were so dense and so extensive that attempt at removal was abandoned. After the peritoneum was closed, a blunt clamp was plunged deeply into the mass; no pus or fluid escaped. Pieces of tissue from the mass and the infiltrated muscle were removed for examination. The wound was then drained and closed.

*Pathological Report* (Dr. B. F. Stout).—"The tissue submitted consists of two pieces; one, what is apparently tumor tissue, and the other a piece of muscle. The former measures 3 by 2 by 1 cm. It has the gross appearance of sarcoma. It is quite firm and non-resilient to the touch; its substance offers considerable resistance to the knife. The cut surface is homogeneous in appearance and pinkish white in color. When the surface is scraped a small amount of grayish material comes away.

"In the small piece of muscle one can see bands of tissue like that described above surrounding the muscle bundles; and in places the muscle itself has been supplanted by the firmer tissue.

"Under the microscope the picture is as follows: A major part of the tissue consists of large oblong cells with a distinct oval nucleus and an ill-defined cytoplasm. These cells vary somewhat in size but for the most part are quite uniform. When seen in cross section, the cell-outline is somewhat flattened and the nucleus round. No definite stroma—or at least no stroma that can be differentiated from the spindle cells described—can be demonstrated. A few small lymphocytes are seen scattered throughout the tissue. No leucocytes are present. The blood-vessels are thin-walled and are surrounded by a small amount of connective tissue.

"This tissue is thought most probably to be inflammatory, although malignancy is a strong second possibility. The cells give one the impression of being fibroblasts rather than sarcoma of the spindle-cell type."

*Postoperative Course.*—Despite this report, it was difficult to convince those of us who saw this case at operation that we were not dealing with malignancy. The element of time was the deciding factor.

On the 2d day after operation the temperature rose to 101 degrees and on the 3d day pus began to drain from the wound in considerable quantities. No sulphur granules were found in the pus. After a few days, the fever disappeared, but free drainage of pus continued for about two months. At the end of a month the tumor had disappeared but the induration of the abdominal wall had extended so that it involved practically the entire abdomen. The patient's condition at this time was considerably improved. The induration gradually subsided and had disappeared in three and one-half months. At this time the patient was able to be up and to do her house-work; she was free from pain and felt well; her bowels were moving regularly. The wound had healed except for an area the size of a ten-cent piece; just above and to the right of the incision a similar-sized granulating, papillomatous area was present.

Both these areas had healed two or three weeks later. A letter from her physician two years after the operation describes her condition in these words: "I had K. B. to come to my office to-day. She tells me she is as well as she ever was, and her looks verify that statement. She looks well, and has gained twelve pounds. Menstruation has re-established itself. There is no discharge from the wound and no soreness or hardness of the abdominal walls."

The outcome of this case leads me to believe it to be an example of what is called inflammatory tumor of the abdomen. This condition, of course, is not a new one; but it is one that has been given a place as a clinical entity by virtue of a more intensive study of tumors, true tumors having thus been separated from pseudo-tumors. The Catalogue of the Surgeon-General's Library, First Series (1893), contains no reference to inflammatory tumors of the abdomen; the Second Series (1913) has less than half a dozen references to the condition. One particular type, namely, inflammatory tumors of the omentum, has received attention for a longer time; Pean, as early as 1880, recognized and assembled a triad of symptoms which he considered diagnostic. A recent paper by Peterhauvahr summarizes our knowledge of this type. This author reports forty-four (44) cases from the literature and of these thirty-six (36) followed previous operations, mostly herniotomies. It is noteworthy that Peterhauvahr makes no reference to the early work of Bull and Coley in this country. Hessert has since added two other cases following hernia operations. About ninety per cent. (90%) of these cases were due to the use of non-absorbable suture material coupled with a probable low-grade infection.

The past few years have produced several contributions to the subject under discussion. Hamann in 1910 considered these inflammatory tumors in their simulation of neoplasms and here one finds the best summary in English of the subject as a whole.

The most recent and most comprehensive communication is a paper by an Italian, Gino Baggio. This author reports two personal cases and contributes a most exhaustive study of the whole subject. In a reasonably short space it will be impossible to do more than epitomize this work.

Baggio classifies the collected cases into two groups, intraperitoneal and parietal. The latter group is probably primarily intraperitoneal, the process having its origin in or about some hollow viscus and involving by adhesion and extension the adjacent abdominal wall. The intraperitoneal group is divided into sub-groups which indicate the region involved, *viz.*, stomach, cæcum, any part of the colon, sigmoid, omentum, liver and bladder. An inflammatory process may begin in any of these locations and gradually assume the size and characteristics of a true tumor.

The pseudo-tumors which sometimes form about ulcers of the stomach and duodenum are probably the best known of the abdominal inflammatory tumors. It is not unlikely that many of the reported cases of gastric resection or gastro-enterostomy for cancer which recovered were only inflam-

matory in nature. It is with this thought in mind, no doubt, that Mayo Robson advises gastro-enterostomy in all tumors of the stomach which cannot be removed.

A particularly interesting group of inflammatory tumors are those which form about a foreign body. They may occur about nonabsorbable suture material either in the abdominal wall or in the wall of some of the hollow viscera. A foreign body in the lumen of the intestine or in a diverticulum may be provocative of sufficient inflammatory response to simulate a neoplasm, and again such foreign bodies as pins, needles, pieces of wood or glass, etc., may migrate into the wall of the bowel, or the wall of the abdomen, with a similar result. Wagner has described a very extensive case in which the cause was found to be part of a metallic instrument left in the abdomen at a previous operation. Doubtless in all these cases the added factor of infections plays a considerable part in the proliferation of connective tissue.

It is interesting to speculate as to the relation of inflammatory tumors to the infectious granulomas and to desmoids. It is easy to understand how syphilis, tuberculosis, or actinomycosis may be responsible for a tumor which is truly inflammatory, but the process would be quite different from the one under discussion. In the one case the causative factor is specific, whereas in the other it may be variable. The use of the Wassermann or other specific tests, therefore, should be resorted to in all cases.

Inflammatory tumors of the parietal type may clinically and microscopically closely resemble desmoids. The term desmoids is one applied to dense fibroid tumors in the abdominal wall which in point of malignancy stand between sarcomas and fibromas. They occur usually in women and are very prone to occur during pregnancy and after parturition. Their etiology is obscure; traumatism no doubt plays a part. Balfour is of the opinion that a predisposition on the part of the individual toward overgrowth of connecting tissue must be present as well. Suffice it to say that without the microscope, or even with it, confusion may arise.

Only a word as to diagnosis will be added, because a definite diagnosis is usually impossible even when the tumor is exposed. A careful microscopical examination is the only certain method of diagnosis and if possible this should be done during the operation before any attempt at radical removal is made.

Baggio epitomizes the treatment in these words: *noli me tangere*. That this conservative plan of treatment is justified is proven by the fact that out of 47 cases collected by him exploratory operation sufficed to bring about a cure in 37. On the other hand, out of 10 cases where radical removal was resorted to, 4 resulted fatally. It should be remarked that in many of the cases collected by Baggio, conservative treatment was used because of necessity rather than by choice. The tumor was considered malignant and its true nature was known only after microscopic examination of an excised piece or after the tumor had disappeared.

With the tumor exposed it is a great temptation to attempt its removal,

but it is the better part of discretion, particularly where important organs are involved, for one to be content with simple drainage and excision of a section for diagnosis. Should it prove malignant, thorough excision may be practised later in suitable cases.

In conclusion, the important thing to remember about this subject is that the existence of inflammatory tumors is a clinical fact. Every tumor-like mass in the abdomen is not malignant and may not be a tumor at all in the true sense of the word. The naked-eye appearance may be misleading and only the microscope can reveal the exact condition. The proper management of inflammatory tumors of the abdomen requires a nicety of surgical judgment which should tend in all cases toward conservatism.

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# ON OSSEOUS CYSTS AND SO-CALLED GIANT-CELL SARCOMA

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TRUE osseous cysts are of a non-malignant nature, and are generally solitary in the large cylindrical bones, more especially in younger individuals. Their etiology has not been determined with any certainty.

Speaking generally, osseous cysts originate from a variety of causes. Thus they may be the result of a past inflammation—infectious osteomyelitis—or of parasitic origin—echinococci and cysticerci; of softening of tumors, more especially chondromas and sarcomas; also of certain osseous diseases with rarification, as senile osteoporosis, common osteomalacia, perhaps also Barlow's sickness, and most often of otitis fibrosa.

If the two former groups are eliminated, the question, as a rule, will be whether the cyst or defect is the result of a tumor or caused by one of the rarefying diseases just mentioned.

After Virchow, the medical world in general accepted the idea of tumors as the main origin of most of the cysts in question, which were considered malignant and treated accordingly. In the course of time a change of ideas took place, and it was pointed out that osseous cysts originating from tumors were far rarer than generally assumed, and that the tissue often was of a non-malignant character, even when its structure resembled that of sarcoma strongly enough to make a mistake possible. In other words, the disease in the bones would be due, in these cases, not to malignant tumors, but to disease of a different nature.

A closer study of rarefying osseous diseases revealed cysts, the walls of which often contain a giant-cell tissue, rich in cells, of sarcoma-like structure, even when the disease could not possibly be regarded as a malignant growth.

The study of one disease especially—otitis fibrosa—shed a fuller light on these problems. Otitis fibrosa seems to occur rather often in certain countries, *e.g.*, England (*cfr.* Paget's disease—otitis deformans) but is rarely seen in Norway in more advanced form. Milder forms, however, with one or few foci are found quite frequently.

As this disease develops, a tissue of a fibrillar character appears in the bones, the marrow is changed into connective tissue, bone substance is resorbed, and cysts, often large, are formed. Side by side with this retrogressive change, a progressive process takes place with new growth of bone or osteoid tissue, and quite often a proliferation of cells so vivid that the tissue produced may easily be mistaken for a giant-cell sarcoma.

In the following I shall try to describe in full this tissue which is of great interest from a clinical as well as an anatomical point of view.

From the examination of solitary osseous cysts it has been learned that the nature of the process is frequently neither simple nor easily explained.

The cyst, or perhaps it would be more correct to say the defective part

of the bone, is often filled with a tumor-like tissue which microscopically would easily be mistaken for giant-cell sarcoma. It must, however, be kept in mind that a similar tissue is found not infrequently in quite small quantities scattered in the connective tissue surrounding smooth-walled cysts, although it cannot here be considered as a typical tumor tissue. Therefore great care must be taken before the diagnosis of sarcoma is made.

Ostitis fibrosa—local or general—closely resembles osteomalacia. In the latter we have more or less tissue, rich in cells, and resembling in structure giant-cell sarcoma, even macroscopically, but the tissue cannot be considered as of typical tumor growth here either.

When a bone cavity is found filled with tumor-like tissue instead of a mucous or serous fluid, the reason may be because the progressive process is strong enough to prevent the formation of cysts. A preparation to be discussed later shows conclusively, according to my opinion, that these two processes may exist side by side. This preparation shows in the tumor-like tissue a number of cysts surrounded by mucous tissue with few cells, partly by tissue rich in cells which forms the main part of the contents of the cavity (Case 4).

Clinical experience shows that bone cavities in so-called giant-cell sarcoma can be cured by conservative treatment, which would not be the case if a true sarcoma were in question.

In this case, as so often in medical science, one method of examination or one isolated symptom is not sufficient for a true diagnosis. Exploratory excisions and microscopic examination frequently lead to the goal, but in ostitis fibrosa experience has taught us that even the disclosures of the microscope may be misinterpreted. If besides the tumor-like tissue a piece of the surrounding bone wall is available for examination it will be a very valuable help to the investigator. As mentioned, in the case of ostitis fibrosa, the marrow is changed into fibrous tissue, accompanied partly by resorption of bone and partly by the formation of new bone.

If, therefore, these changes are found side by side with tumor-like tissue, the diagnosis must be ostitis fibrosa with a giant-cell tumor.

Many authors use the name ostitis fibrosa with giant-cell sarcoma, but the name is not well chosen, as experience shows this tumor-like tissue is benign, whereas osseous sarcoma is not.

Giant-cell tumor therefore must be considered a more correct and more non-committal name for this sort of tissue. The word has been proposed by other authors, but seems to be used but rarely.

Even if only a small piece of the tumor-like tissue is available for examination, the course of the disease with its clinical picture seen in connection with the microscopical appearances precludes the diagnosis of sarcoma, which would otherwise seem obvious at first sight.

The tumor-like tissue is of a peculiar, dry consistency, somewhat resembling the dry substances of thrombi in the heart and veins; it crumbles easily and thus differs from ordinary sarcoma tissue which is much more elastic.

<sup>1</sup> Norsk Mag. f. Laegev., 1915.

The color is generally a dark brownish-red,—in two of my cases large parts of the tissue were yellow.

The microscopic picture, described in detail in each case reported, also shows a peculiar structure which is easily recognized, although it is not possible to give any decisive distinguishing features between sarcoma and giant-cell tumor. If the resorption of the osseous substances can be shown to take place in connective tissue with few cells, if, in other words, fibrous marrow is found, then that fact would indicate that the bone-destroying process is not of a malignant character.

The most striking feature of the disease is the enormous giant-cells with 50 to 100 nuclei in one section. The picture on the whole shows a varied structure with regions rich in cells and bands of connective tissue, often showing hyaline degeneration; between them every variety merging into tumor-like tissue, also bone substance in the process of formation, resorption, and once in a while islands of cartilage. The cells are mainly round or oval, their protoplasm most often clear and well defined in outline; frequently no intercellular substance can be traced.

On the other hand, a giant-cell sarcoma under the microscope shows a more homogeneous tissue, with no such extensive spots where cells are few. The shape of the cells is more like a spindle, the intercellular substance more abundant, and besides the giant-cells we find all intervening stages down to cells with 2 to 4 nuclei—a thing rarely seen in the case of giant-cell tumor.

Many authors are of the opinion that the giant-cells are combinations of osteoclasts; they frequently absorb pigment, and if this can be proved to any extent we have gained a point towards deciding that the tumor-like tissue is not sarcoma, as the latter never shows pigment to any extent in the giant-cells.

We have also been told that if giant-cells are seen in clusters this fact would be an indication that the tumor tissue is part of *ostitis fibrosa*, whereas in the case of sarcoma the giant-cells would be more evenly distributed throughout the tissue. This statement does not conform with the fact of the 9 cases I have studied. They show no pronounced clustering of the giant-cells; in nearly all the preparations the latter are evenly distributed over all parts of the tissue.

The accumulation of pigment in the giant-cells does not seem to be a reliable test. None of the cases show any special preference on the part of the pigment for the giant-cells. If present at all, the pigment is mainly found in the stroma or in the cells with a single nucleus.

Bloodgood insists on the benign character of certain tissue, however much it may resemble giant-cell sarcoma, but in spite of this he still uses the name "giant-cell sarcoma."

Utterström also pleads that the tissue frequently seen in osseous cysts, though like giant-cell sarcoma, is not of a tumor nature, but must be considered as a result of chronic inflammation.

I came to take up this subject by reason of some pieces from a growth in the tibia sent to the laboratory of Professor Harbitz with an inquiry



whether the disease was a sarcoma (Case I). Other cases were placed at my disposal later.

CASE I.—Man, aged twenty years, patient of Dr. Barth, Arendal, had always been in good health, but fourteen months before presenting himself something struck him on the tibia just under the knee-joint, and since then he had a pain in his leg off and on. When seen the upper part of the tibia was swollen, mainly inward.

October 3, 1915, a few small pieces of tissue in tibia were excised and sent for examination.

The tissue was tumor-like, rich in cells, the cells polymorphous, from small round or spindle-shaped cells to large giant-cells with numerous nuclei placed centrally. A series of cells were large, round or oval, with deeply stained nuclei and well-defined protoplasm. Intercellular substance sparse, homogeneous (Figs. 1, 2 and 3). Diagnosis: Giant-cell sarcoma.

At operation, October 11, 1915, a large cavity was found in the bone, filled with brownish-red tumor-like tissue which was carefully scraped out. The outer wall of the bone was as thin as paper and partly affected. In the upper part of the cavity was a cauliflower-like mass which was taken out with the finger; the tissue next to the wall of the bone was a fibrous leathery membrane.

The matter scraped out from the tibia, as much as a small apple in all, was crumbly, homogeneous, on cut surface, brownish-red, infiltrated with hemorrhages. Under the microscope was seen the same polymorphous cell structure as before, moreover considerable fibrillar tissue next to the bony wall is sclerotic with few cells, in which are scattered larger or smaller cellular areas of the same structure as described.

The cavity of the wound became infected, and eight or ten days after the operation an abundant growth of tumor-like tissue appeared, and amputatio femoris was made, the patient, six months after the operation, being quite well, without any signs of recidivation or metastasis.

The amputated part, about 5 cm. below the articular surface of the tibia, showed a wound, 5 cm. by 2.5, which passed into a cavity in the tibia, the diameter of which was 1-2 cm. and length from top to bottom 9 cm. The lateral walls of the cavity were smooth in the upper and lower parts, and consisted of a soft tissue, 1-2 mm. thick, which covered all the underlying bone. At the top of the medial side, and also in the middle, a soft mass of tumor-like tissue bulged.

When the bone was sawed (Fig. 5), the roof of the cavity proved to be a soft tissue which had partly destroyed the spongiosa to the cartilage; 5 cm. below the articular surface the back wall was destroyed to an extent of 3 cm. by 1. In front, about 1 cm. below the medial articular surface the cortical layer was also destroyed and penetrated by a somewhat firmer tumor-like substance of a greyish-white color, the size of a pigeon's egg outside the bone, and well defined from the muscles.

The X-ray photograph (Fig. 6) shows destruction of bone and new bone substance in the periosteum which contains several well defined small cysts in the region towards the head of the fibula.

A section from the spongiosa with the cartilage showed the cartilage to be normal, whereas the underlying spongiosa was more or less destroyed. The space between the trabeculae was filled partly with a finely fibrillar marrow of connective tissue with few cells, partly with a tumor-like tissue rich in cells. Alongside the trabeculae numerous osteoclasts with one or more nuclei (Fig. 7).

A section from the compact bone, just below the affected place, showed the bone in process of destruction, surrounded by fibrous marrow with few cells and with osteoclasts. The spaces where all bone substance had been destroyed were filled partly by the same sort of many-celled tissue as was found in the cavity of the bone, partly with a fibrous tissue with few cells. Several places showed clearly how the bone loses its calcareous matter which is diffused into the connective tissue.

In a section from the marrow at the transitory stage towards the tumor tissue, the bone marrow was changed into fibrous tissue with few cells, with here and there small portions of many-celled tissue; downwards it had changed into normal fat marrow.

A section from the tumor, the size of a pigeon's egg, outside the periosteum showed the growth to be enclosed in a capsule of connective tissue; it consisted of the same giant-cell tissue which has been described.

*Summary.*—Clinically, this case would most likely be regarded as a sarcoma, and as such it was considered by the surgeon who had then no option but to amputate. A favorable result could hardly have been obtained by a conservative treatment, in this case a resection. The bone was destroyed too much; moreover, the articular surface of the tibia would have had to be taken as well. When the cavity in the bone was scraped, some of the tissue was left. The mechanical irritation at the operation with the secondary infection in the wound may have caused the prolific growth of the remaining tissue—a recidivation which all the same is no proof that the tissue was of a malignant nature. From the description of the preparation we learn that the tumor-like tissue had penetrated through the periosteum and grown outside the same but without infiltrating the muscles. The tumor was well enveloped in a capsule of connective tissue, indications that the tissue was not malignant.

The Röntgen photograph does not show the picture commonly found in *ostitis fibrosa*. The destruction of the bone is remarkably diffuse with a growth of tumor-like tissue outside the periosteum, a fact that suggests sarcoma, but as several authors have pointed out, the Röntgen photograph gives but little help in doubtful cases. In this case it would indicate a sarcoma, while a series of other things, more especially the microscopic examination, indicate an *ostitis fibrosa*. The bone-marrow is to a great extent changed into fibrous tissue and the destruction of the bone proceeds mainly from this tissue, which would not be the case in sarcoma in which the tumor tissue destroys and perforates the bone. The many-celled sarcoma-like tissue does not grow in the connective tissue with few cells till after the destruction of the bone has taken place. It is true that in a few places towards the articular surface we see that the tissue lying close under the bone trabeculae destroys them, but this may quite possibly be due to the remarkably rapid growth of the tissue after the operation.

The main feature of the tumor-like tissue is the polymorphous cell picture, showing large round cells with a well-defined protoplasm; the numerous giant-cells, and, alternating with this tissue, the fibrous portions with few cells, points which distinguish it from an ordinary sarcoma which generally shows a more homogeneous growth, less polymorphous cell formations and has not any fibrous, poorly cellular portions, which show all stages up to the rich cellular tissue.

Anatomically this case must be considered as an *ostitis fibrosa* with giant-cell tumor.

There is in favor of this diagnosis also the fact that the patient after six

months showed no sign of recidivation or metastasis. Sarcoma of the bones is well known for its malignity, and here we see no recidivation in spite of the fact that the skin was not more than one cm. distant from the tumor-like tissue growing outside the periosteum.

A sarcoma of that size with such proliferation of cells would hardly have given so satisfactory a result.

Similar cases have been described by several authors. Bloodgood has written exhaustively on this subject, on the basis of 89 cases of osseous cysts, partly seen by himself, partly collected from the literature, and in 53 of these there were growths with a more or less pronounced resemblance in structure to that of giant-cell sarcoma. Bloodgood calls them sarcoma, but states that they are benign and that conservative treatment is indicated. His cases were treated partly with curettement, partly with resection or amputation; they all had one feature in common, viz., that in no case did metastasis occur. In a few cases the periosteum was perforated, and there was a tumor-like growth in the soft portions; the patients were cured by resection.

Other authors describe the occurrence of metastases, but judging from their descriptions their cases seem to have been multiple foci of the same disease; metastases in glands or other organs have not been found.

**CASE II.**—A fisherman, forty-six years old. Service of Professor Bull. Trauma in the knee region ten and three years ago.

October 17, 1913: Some atrophy of right leg; upper part of tibia somewhat thick; normal mobility in knee-joint. The Röntgen photograph showed a considerable destruction in the upper end of the tibia which was swollen and the corticalis changed into a thin shell, indicating cavities varying in size up to that of a hen's egg. Between them, thin dividing walls will be seen. The outline not very sharply defined (Fig. 8).

At operation the cortical bone layer in the swollen part was 1-2 mm. thick; by chisel a large cavity was opened from which about 100 grams of yellowish tissue mixed with blood-coagula were removed with a sharp spoon. A secondary cavity down towards the medullary canal was filled with a more firm tissue, near the outside fibrous, the surface of greyish and greyish-yellow color, while the inner portion was a brittle, necrotic material, the color of ochre.

February 6, 1914: The cavity granulating; holds 90 c.c. of water.

April 15: Little secretion: cavity holds 50 c.c. of water.

April 28: Patient leaves the hospital; cavity holds 45 c.c.

Nine months later the cavity holds 35 c.c., slight discharge, without smell. Two and a half years after the operation the cavity holds 10 c.c. of water; no sign of recidivation.

*Microscopic Examination.*—The firm tissue in the lower part of the cavity is fibrous with comparatively few cells having long narrow nuclei. The layers of cells are divided from each other by an abundance of striped intercellular substance partly showing hyaline degeneration (osteoid tissue?), and which in some places seem to form masses of a more pronounced color—a commencing calcification.

Areas of cellular tissue are seen, with spindle-shaped or round cells of a somewhat larger size, also groups of fat-containing cells. On the inner side towards the yellow substance the tissue becomes more rich in cells, the latter are more polymorphous, an increasing number contain fat. The cells are round, oval or spindle-shaped, partly with and partly without distinct intercellular substance. In many of the round cells the outline of the protoplasm is well defined.

Furthermore there is a plainly osteoid substance with small cells in heaps and an abundant intercellular substance, also newly formed bone-substance, resembling spongy bone, with intermediate stages of osteoid tissue with calciferous deposits, the osteoid portions appearing as part of the tumor, and are not surrounded by osteoclasts. Bone trabeculae in process of resorption are seen covered with osteoclasts; between the trabeculae is connective tissue with rather few cells. Numerous giant-cells are scattered throughout, irregular in shape and outline, with numerous nuclei non-pigmented; fat-containing cells for a great part of the tissue (note the yellow color); they have small round nuclei in the centre of a protoplasm with a fine reticulum and vacuoles. Diagnosis, sarcoma of tibia with polymorphous cells.

Clinically the disease was considered as benign and the patient was treated conservatively by scraping the cavity; two and a half years later the cavity had nearly filled itself, with no sign of recidivation or metastasis. We may therefore conclude that there was not a malignant tumor. The cellular tumor-like tissue with new bone substance is due to a productive process in the connective tissue, going on side by side with the bone destruction. A closer examination of the microscopic preparations also indicates that the diagnosis of sarcoma was not correct because sarcoma does not show so heterogeneous a character with large poorly cellular fibrous portions with intermediate stages up to a cellular tissue; nor does sarcoma show osteoid tissue and new bone as in the present case. In the parts showing destruction of bone, the trabeculae are surrounded by fibrillar tissue; that is, it is not the tumor tissue that destroys the bone, as would have been the case in sarcoma. The giant-cells are not so large as they frequently are in *ostitis fibrosa*, nor does the tumor-like tissue contain so many round cells with a clearly defined protoplasm as is often the case.

Hence, the case may be considered as a local *ostitis fibrosa* with giant-cell tumor in which the productive process has filled up the defect in the bone as quickly as bone was absorbed. Besides the usual cellular tissue, a quantity of yellow tissue was found, with fatty cells that must be considered as young fat tissue. The fat only formed small drops in a fine network in the protoplasm and the nucleus was central. This tissue appeared to originate from the same elements as the tumor-like tissue and formed an integral part of the tumor.

I have found nothing quite similar in any of the cases I have studied. In Case V a yellow and reddish-brown tissue was found in the cavity, but the yellow tissue does not appear to have been specially examined by microscope, so that it is impossible to decide whether it was fatty.

This finding has, however, hardly any differential value and is probably a rare occurrence in *ostitis fibrosa* and is seen also in sarcoma.

CASE III.—Man, aged twenty-four years, service of Professor Bull. Always well, no known trauma. A little before Christmas, 1905, pain in the leg, and shin somewhat swollen at Christmas-time, otherwise well. The swelling has grown constantly but has not hampered him in any way, so that he was even capable of military service that summer.

## OSSEOUS CYSTS AND GIANT-CELL SARCOMA

August 2, 1906: Between the upper and middle third of right tibia is a swelling 8-10 cm. in length, hard as bone, of even surface, skin normal.

August 3: Incision and opening by chisel of a cavity in the tibia about the size of a goose egg, filled with a dark brownish-red fluid. The inside was partly covered by a thin gelatinous membrane. The whole of the thin bone lamella which formed the medial wall of the cyst was loosened from the soft parts and taken away. A smaller cavity was found also, the size of an almond, filled with a firm tissue, and connected with the medullary cavity.

August 24: The wound healed. Ten years after the operation the patient states that he is in perfect health and has had no signs of any bone disease since the operation.

The microscopic preparations of the cyst wall show a varied tissue, partly cellular and tumor-like, partly mucous with few cells; the latter appears to have formed the inside of the membrane. The cellular tissue consists of round cells with a distinct, well defined protoplasm of spindle-shaped cells with an abundance of finely fibrous intercellular substance, and of numerous giant-cells with central nuclei. In several places small masses of newly-formed bone are seen. In one place is seen bone resorption surrounded by fibrillar tissue. The firm tissue in the small cavity was not examined.

Generally fibrous osteitis attacks the spongy portion of the bone; in this case it must have originated in a canal in the shaft of the tibia. A part of the bone was destroyed with the formation of a cavity succeeded by exudation which caused the periosteum to swell and new bone to form so that the peripheral part of the cyst was covered by a bony shell as thin as paper. At the same time there was proliferation of cells and formation of a tissue resembling giant-cell sarcoma in the thin membrane surrounding the cyst and in a small area outside, the latter unfortunately was not examined microscopically.

The cellular tissue resembles very much giant-cell sarcoma, the diagnosis given immediately after the operation. Clinically, however, the disease was regarded as benign and conservative treatment cured the patient. No recidivation after ten years proves the process was not malignant.

In the museum of this institute are two preparations, which show the typical characteristics of osteitis fibrosa, from Dr. Jervell, who gives the facts now known as to one of the patients, the fate of the other is unknown.

CASE IV.—Left leg amputated 24 cm. above the lower end of the femur; knee joint normal; palpation of the outer cartilage of the tibia shows that it yields to pressure; the upper end of the tibia is much swollen and after being sawn through shows a growth, 7 by 8½ cm., of a round or faintly oval shape; the outline is well defined, bounded above by cartilage, laterally and in front by periosteum, in which some spicula of bone are scattered, below by a saucer-shaped depression above the point where the marrow cavity begins (Fig. 9).

The substance of the growth consists of a soft, rather brittle tissue, containing, more especially in the middle part, a great many cavities, varying in size from quite small up to that of an ordinary dried bean, and filled with coagulated blood or a colorless substance resembling colloid. The surface thus looks like a network with beams and islands of tumor-like tissue, embracing cavities (Fig. 10) with colorless or dark, partly blackish-brown contents.

Microscopically, the cysts are surrounded partly by a myxomatous tissue, partly by a cellular tumor-like tissue, the cells of which are polymorphous, some

small and round, some spindle-shaped, some large, round or oval; of the latter many have a well-defined protoplasm. Scattered in all parts of this tissue are numerous large giant cells with more than 50 nuclei in one section. The nuclei are massed together in the centre of the cell (Fig. 11). In most parts of the tissue there is a finely fibrillar intercellular substance. Besides, fibrous parts are seen, in one place with a cluster of giant-cells (Fig. 12). A rudimentary formation of new bone occurs at several places in the cellular tissue.

Sections from the borderline between the tumor-like tissue and the bone marrow show a sudden change from the normal fatty marrow to the tissue described.

Destruction of bone takes place in the fibrillar connective tissue in the canals and the marrow cavities, the trabeculae being studded with osteoclasts with one or several nuclei. The bone changes into connective tissue and a profuse proliferation of cartilage is seen at several places in the latter. The cellular tumor-like tissue is found within these parts.

This is the case which I mentioned as showing the formation of cysts side by side with the growth of tumor-like tissue. In this case, as in the others, it is not the cellular tissue that destroys the bone, but the more fibrous, and in the connective tissue thus formed is a growth of cellular tissue in larger or small areas. As in the other cases of *ostitis fibrosa* with tumor, we find a heterogeneous tissue, fibrous portions alternating with cellular tissue, and myxomatoid tissue is formed in profusion. In one section, cartilage is found and also new bone formation in many parts of the cellular tissue. Giant-cells occur in great numbers, and their nuclei are exceedingly numerous; the other cells are polymorphous, round, oval or spindle-shaped, altogether a picture that decidedly speaks against sarcoma. We see the whole of the tumor-like tissue honeycombed with cysts formed by softening in the myxomatous tissue (Figs. 11 and 12). Macroscopically, the periosteum is unbroken in spite of considerable swelling and formation of cellular tissue. No metastasis occurred. The conclusion to be drawn from all these facts is that the case cannot be considered to be a sarcoma, and the diagnosis must be *ostitis fibrosa* with giant-cell tumor.

CASE V.—Woman, twenty-nine years old. During recent years pain across right instep; in April, 1902, a tumor was found corresponding to *os cuneiforme* 1. Operation in September, 1902, showed this bone to be changed into a rather soft mass, with a cavity the size of a hazelnut, and filled with a serum-like fluid. The process was limited to this bone, which was taken out; thirteen years later, no recidivation or metastasis.

The microscopic preparations show a cellular osteoid substance with spindle-shaped and star-shaped cells and homogeneous intercellular material. In this tissue are areas of tumor-like cellular tissue consisting of polymorphous cells of a character resembling connective tissue. Many of the cells are large, round or oval with a well defined protoplasm. Numerous giant-cells with clusters of nuclei placed centrally occur throughout the tissue; the protoplasm in some of them contain vacuoli. The intercellular substance is partly homogeneous, partly finely fibrillar. The borderline of the osteoid tissue is clear and sharp, and in several places giant-cells are ranged in rows alongside.

Just under the cartilage is osteoid tissue with bone spicula, set with osteoclasts and surrounded by connective tissue, not particularly rich in cells—a fibrous

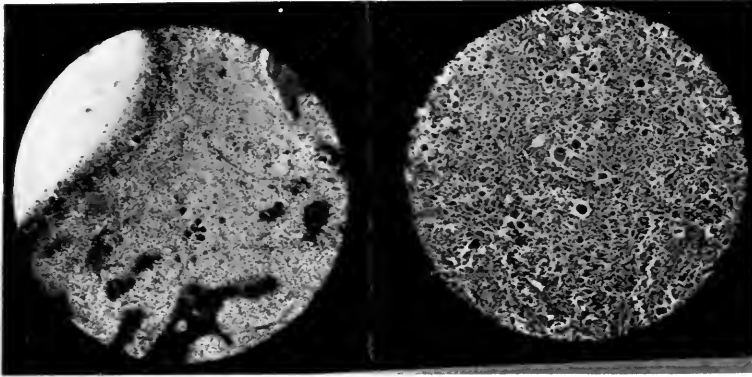
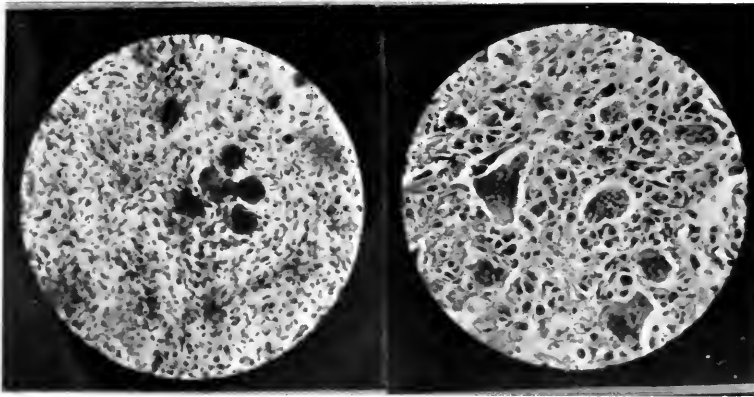


FIG. 1.—Case I. Above to the right is seen the wall of a cyst bordered by a tumor-like tissue containing giant-cells. The rest of the tissue is also cellular and contains giant-cells.

FIG. 2.—Case I. The same preparation more magnified. The polymorphous character of the cells greatly resembles the tissue which is described later as giant-cell tumor in *ostitis fibrosa*.



FIGS. 3 and 4.—Case I. Same preparation as in Fig. 2, more magnified. Besides the giant-cells, are polymorphous cells, mainly round, and many of these have a well-defined protoplasm. The intercellular substance is sparse, homogeneous.



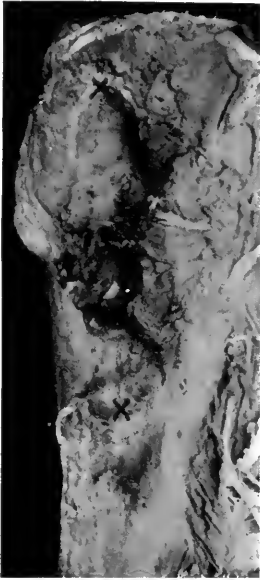


FIG. 5.—Case I. A photograph of the tibia sawed through. The extent of the bone cavity is marked by two crosses. Above the articular cartilage may be seen, with the destruction of the spongiosa nearly reaching it.



FIG. 6.—Case I. Röntgen-ray photograph of tibia.



FIG. 7.—Case I. Bone in process of resorption surrounded by non-cellular connective tissue, which must be regarded as fibrous marrow; to the right is shown the same cellular tumor-like tissue as in Figs. 1 to 4.





FIG. 8.—Case II. Röntgen photograph of upper end of tibia.

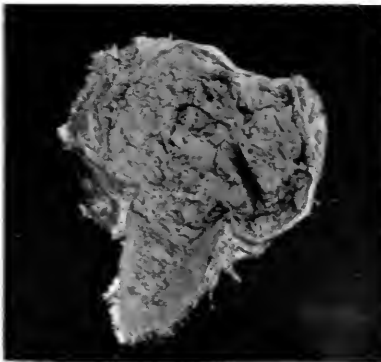


FIG. 9.—Case IV. Photograph of tibia sawed through. The articular cartilage is seen above, below the shaft of the tibia with saucer-shaped depression in the spongiosa. The compact layer is destroyed, its place taken by a growth that has infiltrated the periosteum perforating it. At the right the small cysts mentioned in the text are seen as small light patches.

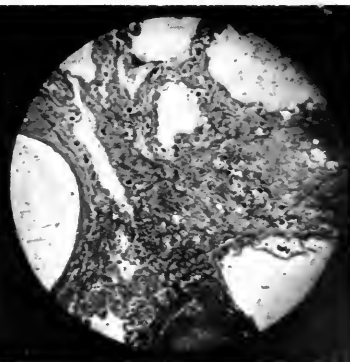


FIG. 10.—Case IV. Cellular tissue, interspersed with cysts.

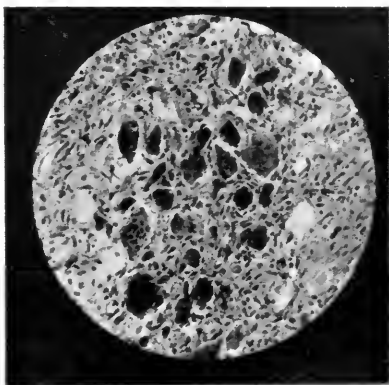
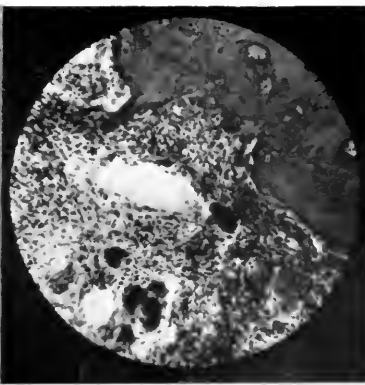
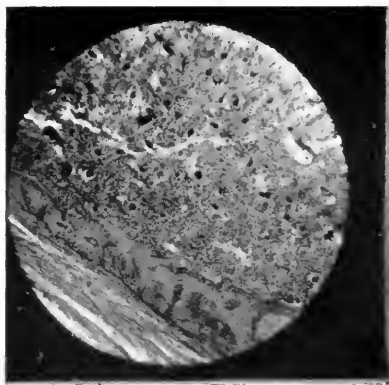


FIG. 11.—Case IV. A cluster of giant-cells; also polymorphous cells, round and spindle-shaped.



FIG. 12.—Case IV. Fibrous area with a cluster of giant-cells.



FIGS. 14 and 15.—Giant-cell sarcoma. Destruction of the bone proceeding from the cellular tumor-like tissue. In the narrow cavity a tissue containing fat without any indication of destruction of the bone and with no osteoclasts.



FIG. 13.--Case IX. Caput fibulæ, swollen, containing cyst of irregular outline; the surrounding bone shell as thin as paper; borderline towards the soft part well defined.



marrow with hemorrhages. Small islands of cartilage with transition to bone are present. Several small cysts are seen in the osteoid substance. They are partly filled with structureless matter, and their walls contain giant-cells.

There is no mention made of any trauma. During two years the patient suffered pains in the foot. Operation reveals an isolated destruction of one bone of the tarsus, with formation of cysts and a new growth of tumor-like tissue. The surrounding tissue was not affected, and the patient was cured by conservative treatment, consisting only in the removal of the diseased small bone. The microscopic diagnosis was given as giant-cell sarcoma, but such interpretation of the preparation is hardly correct. The clinical course of the illness, when in two years only one small bone was destroyed without any damage done to the surrounding soft parts, as well as the favorable result of the conservative treatment, make out a strong case against the assumption that the tumor-like tissue was of a malignant character.

The microscopic picture shows that the cellular tissue is built up by the same polymorphous cells as in the cases of *ostitis fibrosa* with tumor; there are islands of cartilage with transition to new bone and the few bone fragments left are surrounded by a connective tissue—facts that conform with those of *ostitis fibrosa*.

The peculiar feature of this case is the profuse growth of new osteoid tissue. This tissue corresponds to the fibrous portions regularly occurring in sections from the tumor-like tissue described in other cases. Cysts, with or without cellular tissue, are found in this tissue.

It would appear that in this preparation the destruction of bone substance starts from fibrillar tissue; so little is left, however, of the original bone that it is impossible to ascertain the point definitely.

From what is stated, it appears that clinically and microscopically the disease must be regarded as non-malignant, and as a case of *ostitis fibrosa* with giant-cell tumor in a rare localization.

CASE VI.—Woman of thirty-nine years (Dr. Holst, Trondhjem). Seventeen years ago the wheel of a trap went across the right leg a little below the knee; in 1908 periodical pain developed in the middle of leg, later in the upper part of tibia, more especially at the external condyle where a protuberance appeared. The protuberance grew, especially after an injury a fortnight before the operation. A swelling was seen in the upper anterior part of the tibia, most pronounced under the external condyle where there was a small soft, pseudo-fluctuating area, while the rest was firm and hard. No effusion in knee-joint.

In the röntgenograph a cavity about the size of a small hen's egg appears in clear outline, in the upper part of the tibia.

Operation, February 22, 1908.—A bony layer, nearly as thin as paper, covered a well-defined cavity in the bone, filled with a yellowish soft tissue that in some places had the consistency of putty, and also contained some reddish-grey matter. The cavity, which had firm long walls, was thoroughly scraped. An opening about as big as a pea in the back wall led to the muscles beyond, which, however, showed no sign of being affected.

April 8: Bone cavity filling up, good granulations. Soon after the patient got up, her wound healed. During the six years since her operation she has felt no ill effects from her illness.

The microscopic examination of the greyish-red matter showed a cellular tissue, the cells closely packed but not in any characteristic order. The nuclei were rich in chromatin, round or oval, and had the appearance of those of connective-tissue cells. The most characteristic feature of the tissue, however, was

the great number of giant-cells, scattered evenly throughout the tissue, with numerous nuclei, generally closely packed together in the centre of the cell; in a few isolated cases the nuclei were at the edges. There were no signs of osseous degeneration or tuberculous arrangement. The growth had a few blood-vessels in some parts, in others the vessels were fairly frequent.

Diagnosis: Myeloma tibiæ (Myelosarcoma—Sarcoma gigantomatosa).

Neither the röntgenograph nor the microscopical preparations have been preserved; thus a more detailed study of them is out of the question.

The history of the case, and most of all the favorable result of a highly conservative treatment, prove the disease to have been of a benign nature. The macroscopic appearance of the tumor tissue, the brownish-red matter, corresponds to the tissue described in other cases. The cavity in the bone was well defined, the compact tissue thin as paper without any pronounced changes in the periosteum, which was perforated at one place without causing any infiltration in the adjoining soft parts. These facts seem to make the accuracy of the microscopical diagnosis rather doubtful.

The yellow putty-like matter does not appear to have been examined microscopically. From some cause or other the tissue had become necrotic and if the operation had been delayed, this tissue would probably have been resorbed and we should have found a cavity surrounded by tissue as described in the other cases. The tissue might also have been of the same description as the yellow tissue in Case II, *i.e.*, young fatty tissue. But there is nothing in the microscopical description that does not conform with the conception that the disease was osteitis fibrosa with giant-cell tumor, and in my opinion that is the correct diagnosis. It is difficult to see any connection between the disease and a trauma 21 years before, but the possibility is not wholly precluded that a hemorrhage in the spongy part at the time may have created a predisposition.

**CASE VII.**—Boy of fifteen years, Dr. Sinding-Larsen. Patient in good health previously. Fell off bicycle June 22, 1916, and broke right upper arm. The Röntgen photograph showed besides the fracture a swelling of the upper end of humerus up to the cartilage of the epiphysis, with cysts with well-defined borderlines. The fracture was located in the lower part of the swelling and one month after the accident a formation of callus was clearly visible in the transitory region towards normal bone. After plaster bandage for four weeks there was consolidation of the fracture.

The operation, July 26, 1916, revealed a cyst nearly as large as an egg filled with bloody matter; the inside of the walls was covered with reddish-brown matter resembling granulating tissue. The bone underneath was smooth; no apparent connection downwards with the marrow cavity. Tamponade.

In section the matter scraped out proved to consist mainly of a poorly cellular myxomatous connective tissue. The bone showed typical alteration, trabeculae were surrounded by a connective tissue which had destroyed the bone, so that the slow transition to fibrous tissue was clearly visible. Some of the bone fragments were covered with osteoclasts. In a few places there was a tissue with more numerous cells, which latter were polymorphous, some round, some oval, some small and spindle-shaped with abundant intercellular substance. Isolated giant-cells were scattered about.

A considerable alteration of the bone had developed in this patient without any symptoms. A trauma caused a fracture of the weakened shaft and the Röntgen photograph reveals an unknown disease of the bone, viz., a cyst with swelling and considerable destruction of bone. The fracture caused a lesion of the thin bony capsule so that the new tissue in the bone no longer was separated from the soft parts by a bone wall. After four weeks the fracture is fully consolidated, and there is no indication of growth at the line. These facts prove that the disease in the bone must be benign, a supposition which was confirmed by what was found at the operation. Under the microscope bone substance is seen to be replaced by connective and myxomatous tissue, which formed the bulk of the matter scraped out. In some portions there was cellular tissue with polymorphous cells and giant-cells. Without any doubt this tissue is of the same character as the tissue described in the other cases, and in spite of its numerous cells it must be considered as benign.

From a clinical point as well as anatomically we have here a typical case of osteitis fibrosa, but not till a series of sections have been examined did we find those cellular tumor-like areas of the same character as in the other cases where the tumor-like tissue sometimes formed the bulk of the matter taken out. In my opinion this case shows clearly the connection between osteitis fibrosa and giant-cell tumor. The proliferation of cells is slight and there is no giant-cell tumor, but the main feature is the destruction of bone substance. In other cases, as for instance in Case III, the growth of cells is more pronounced, while all the time a decided formation of cysts goes on. In other cases again, the proliferation of cells is so active that the formation of cysts becomes of secondary importance and we have a purely productive process with formation of a tumor-like tissue resembling a giant-cell sarcoma to the point of being mistaken for one. All these cases represent an osteitis fibrosa with giant-cell tumor, the latter more or less pronounced.

CASE VIII.—Boy of ten years, Prof. P. Bull. In March, 1916, a small protuberance was discovered by chance on left side of the lower jaw; it grew slowly and was not sensitive. On September 3, a swelling as big as a walnut could be felt on the lower jaw at the foremost molars which was removed the following day. At the incision into the tumor the knife was felt to perforate a thin plate and to enter a cavity filled with softer tissue. No fluid exuded. The cavity was carefully scraped. It was as big as an almond, with smooth walls. Tamponade. The matter scraped out brownish-red and soft.

Microscopically, the tissue is heterogeneous, showing all stages between a connective tissue rather poor in cells and a cellular tumor-like tissue with numerous and large giant-cells. The cells are polymorphous connective-tissue cells, some round or oval, of varying size, as a rule with abundant intercellular substance. Large portions consist of a myxomatous tissue more or less cellular, with a profuse sprinkling of giant-cells. The tissue is infiltrated with fresh hemorrhages. No portion of the bone was available for examination.

On the jaw of a child a protuberance grew slowly without any pain. Six months after the discovery of the tumor operation revealed a cavity as

big as an almond, with smooth walls, as thin as paper in the direction of the mouth and with no changes in the periosteum. This cavity contains a soft tumor-like tissue, which microscopically must be identified with tissue described in the other cases. Here also we see an extraordinary variety of tissue with all stages between fibrous and sarcoma-like tissue with a number of large giant-cells. The greater part of the cells are spindle-shaped, but there are also smaller and larger oval cells, partly with, partly without intercellular substance. There is no stroma, as is usual in the case of a typical tumor, and no infiltrating growth of cells.

The process must be considered as *ostitis fibrosa* with giant-cell tumor in a rare localization and at an early stage. We cannot yet know as to the final result of the operation but in all probability the conservative treatment was sufficient.

**CASE IX.**—Man of twenty-eight years, Dr. Christensen, Aker Hospital. The patient felt tired in the right lower leg during the previous three months; during the last three weeks pains and a pronounced sensitiveness to pressure above the head of the fibula. No trauma.

The Röntgen photographs (Fig. 13) reveal a cavity, barely as large as an egg the outlines of which are not quite clear, and a corresponding swelling of head of fibula. The bone shell is as thin as paper, somewhat irregular, but not penetrated by tumor tissue in any place.

Operation, September 22, 1916. Soft parts normal, periosteum not thickened; a thin lamella was removed and behind it was a cavity filled with greyish, crumbling, tumor-like tissue, which was easily scraped from the smooth walls of the cavity.

Sections of a series of pieces show a polymorphous appearance: There are large and small fibrous portions with few cells and cellular tumor-like tissue with large giant-cells in great numbers. The cells are heterogeneous, some are rather large, round or oval with vividly colored nuclei and distinct protoplasm, others are smaller or spindle-shaped with abundant intercellular substance. In several places there is a network of tissue of an intensive red color (van Gieson) surrounded partly by a finely fibrous tissue, partly by the tissue just described containing giant-cells. In several places its diffusion into or transition to the surrounding tissue is clearly discernible. At one place a small quantity of calcareous substance is surrounded by a lax, connective tissue which distinctly merges into the network just mentioned. The latter must be remnants of spongy tissue in the head of the fibula.

Sections from the walls of the cyst show destruction of bone in connective tissue with rows of osteoclasts—of which many are giant cells—along the bone fragments. The cellular tissue is seen in many places lying close to the bone, destroying it. On the outside of the bone lamella is formation of new bone starting from the periosteum.

Clinically, the complaint was considered benign and treated accordingly in spite of the fact that the microscope showed the tissues scraped out to be exceedingly rich in cells. The destruction of the bone takes place for the most part in a tissue of few cells, in some places, however, the tumor-like cellular tissue is seen in close proximity to bone. The tissue is homogeneous in so far as the fibrous portions merge successively into the cellular parts. There is no connective-tissue stroma with infiltrating growth of cells.



The cells are polymorphous. In several places along the bone trabeculæ there are giant-cells which must be taken to be osteoclasts. They have the same shape and appearance as have the giant-cells we find scattered in the tissue, a fact that indicates a common origin.

All these facts make me inclined to think that this case also should be considered a case of *ostitis fibrosa* with giant-cell tumor.

There is a considerable resemblance between this case and Case I. In both the proliferation of cells is so profuse as to make the microscopic picture like that of a sarcoma.

It may be of interest to compare these cases of giant-cell tumor with the following case of giant-cell sarcoma, of decidedly malignant character both clinically and anatomically.

Man, thirty-six years old, two years ago became aware of a small protuberance as big as a pea and hard as bone on the inside of the radius just above the joint. It was removed, but returned five times before amputation was made in November, 1901.

The radius was swollen, its surface uneven with tumor growth on the outside of the periosteum. The articular cartilage was affected. When sawn through a great part of the radius was replaced by a large growth; throughout parts of which were spicula. The sections from the growth present a homogeneous aspect. It is a very cellular tissue of small round or spindle-shaped, atypical connective-tissue cells with abundant intercellular substance. In all parts of the tissue numerous giant-cells are scattered. Sections from the compact bone show the replacement of the bone to proceed from the tumor tissue (Figs. 14 and 15). It is not possible to demonstrate any fibrous marrow and the destruction of bone proceeding from a connective tissue with few cells.

At first sight we here seem to have before us the same giant-cell tumor described in the preceding cases, but a closer examination soon shows differences that justify another diagnosis, viz., *sarcoma*. The destruction of the bone is evidently due to a growth of cellular atypical tumor tissue. In no place do we find the destruction taking place in a poorly cellular connective tissue or fibrous marrow, as demonstrated in all the previous cases.

The tumor tissue is more homogeneous, with no large fibrous areas, the cells mostly spindle-shaped or small or round. Altogether the case differs widely from what is described as giant-cell tumor accompanying *ostitis fibrosa*. Clinically this tumor moreover showed its malignant character by repeated recidivations.

The localization of *ostitis fibrosa* shows that the parts of the osseous system most often affected are those exposed to the heaviest pressure. Thus Wilken found that of 33 cases the femur was involved 13 times, the tibia 7, the humerus 4, and various other bones 8 times. Other authors mention the tibia as most often attacked. Of the nine cases described now the disease had its seat five times in the tibia, once in the fibula, once in the humerus, once in the lower jaw and once in *os cuneiforme*. In the cylindrical bones the disease is mostly found in the epiphysis.

The patients frequently give a trauma as the cause of the condition. This fact occurs too frequently to be overlooked; it is doubtful, however, whether the real cause is to be found here. As far as I know, no one has

described bone cysts caused by or as a consequence of fractures or infarctions. Moreover, contusions of the bones, and more especially of the bones most often affected, occur so frequently that osteitis fibrosa would have to be reckoned among the common complaints if a trauma would produce it, whereas now it must be considered rather rare. Also, general osteitis fibrosa with foci in practically all parts of the osseous system indicates other causes than trauma.

Beneke (1904) tried to explain the bone cysts as arising in the same manner as an apoplectic cyst arises in the brain. Accordingly a trauma would cause a hemorrhage in the spongiosa, with a subsequent destruction of bone substance. After the resorption a cavity would be formed which would not break down on account of the rigid walls. Our experience concerning traumas in the osseous system and Lexer's experiments on animals are decidedly against this view. The bone that shows a formation of cysts after a trauma was not normal before. The disease was already developing or latent in it. v. Recklinghausen thought that the cause of the disease was a disorder in the circulation, *i.e.*, embolism or thrombosis in the finer vessels of the bone. Other authors again supposed the process to be due to bacteria, a virulent species of the common pus microbes. This theory has never been proved, all experiments to cultivate microbes having been negative or at least doubtful. From a purely anatomical point of view the structure of the tissue does not point to the existence of an inflammation in the ordinary sense of the term. It is a task of the future to find the cause of this malady, which must be considered as a general disease of the osseous system, occurring at an early age, most frequently with isolated foci in the epiphyses of the long bones, in later years with multiple foci in the whole of the skeleton.

Now and then in cases of osteitis fibrosa one meets with cartilage. After Virchow's (1876) description of a case of cysts in the humerus with abundant cartilage in the wall, several authors have tried to explain osseous cysts as the results of dissolved chondromas, even in cases where no cartilage was found in the wall. There is no doubt that cysts may be formed within chondromas but this fact is of no importance for the question of the cause of osseous cysts in general. Cartilage is formed contemporaneously with the formation of new osteoid tissue and bone but without any connection with the cause of the process. The cartilage therefore is generally found as smaller or larger "islands" in the osteoid tissue of the new bone.

#### CLINICAL SUMMARY

The patients are young, as a rule less than 20 years old. Older persons (over 50) are, however, also mentioned as suffering from the disease. The history of the disease remarkably frequently begins with a trauma. Sooner or later after this the patients get rheumatic pains in the injured limb.

Very slowly, sometimes during several years, the bone swells, partly because the main cyst increases in size, partly because of a profuse growth of tissue containing giant-cells; or the tissue softens and cysts are formed

with no swelling of the bone. This state of things may go on unchanged for years. The diagnosis is given as rheumatism, sciatica, etc., until a slight trauma causes a fracture or the bone bends little by little as it becomes too weak to stand the pressure upon it.

The general health of the patients is invariably good. Notice, for instance, Case III, the patient doing his military service with a large tumor of the tibia. Palpation reveals an even hard swelling of the affected bone, not sensitive and with the soft parts moving freely over it. Sometimes it crackles like parchment, the bony wall having become as thin as paper.

The Röntgen photograph is of great help; it is often so typical that the diagnosis is obvious. On the other hand, even a Röntgen expert may sometimes doubt whether there is a sarcoma or not. The typical photograph of a benign osseous cyst shows the latter as one or more well-defined cavities surrounded by a bone shell frequently as thin as paper with no changes or hardly any in the periosteum. The bone may be more or less deformed, swollen or bent.

The description of the osseous cysts may be mistaken for a sarcoma, but in the case of the latter the outline is not so clear, at least not at a stage in the disease advanced enough to offer clinical symptoms. The sarcoma grows more quickly, destroys the bone more unevenly and the periosteal changes come early. Both bone and periosteum are perforated and there is a diffuse and infiltrating growth in the soft parts.

A case of *ostitis fibrosa* with giant-cell tumor may yield a Röntgen photograph so strongly resembling that described for a sarcoma that a mistake is unavoidable. The slow growth, however, combined with the general good health would argue against a diagnosis of sarcoma and the descriptions would hardly be quite alike.

The outline of a giant-cell tumor is always sharper than that of a sarcoma. If it does penetrate the periosteum the tumor tissue grows out into the soft parts without infiltrating them and bone spicula are exceedingly rare in this tissue.

The Röntgen photograph may be mistaken for other conditions of which the following are the most important: Central gumma, which, however, always shows heavy periosteal deposits. Abscess of the bone as a rule also involves periosteal changes. Echinococci of the bones have distinctly separated bubbles. Tuberculosis, if there is one isolated focus in the epiphysis, may be difficult to distinguish from an osseous cyst. The patient, however, as a rule, is younger than those who suffer from osseous cysts, and before the compact layer grows, as in the case of osseous cyst, the periosteum is affected or perforated and a tuberculous abscess is formed.

Mikulicz has formulated his opinion of osseous cysts as follows:

1. It is a disease of the growing period. Of 24 cases, 20 were under 20 years old, 2 under 30 and 2 over 30. In cases in older individuals it must be considered as carried from younger years.
2. The illness preferably affects the long cylindrical bones, and more especially the parts where growth is strongest.

3. The initial trauma is of some importance. It may date back months or more. The process is altogether benign. The tumor tissue that is found does not metastasize, nor does it return, and in case of spontaneous fracture there is abundant formation of callus with complete cure.

All authors seem to agree that local osteitis is found most frequently in individuals under 20 years of age.

The age of the nine cases described here—16, 35, 29, 28, 24, 20, 15, 10, and 1 unknown—with an average of 26 years—is somewhat higher than that which others have stated, but the cases are too few for any valuable deduction from them on this point. It should be borne in mind though, that of nine cases, eight were cases of tumor-forming osteitis fibrosa.

The *treatment* is exclusively surgical, but as conservative as possible. Where there is a smooth-walled cyst with serum-like contents, it is sufficient to remove the latter, scrape the walls carefully and push in the thin bony shell. Then the periosteum will form callus in abundance and the process is healed. If the cyst has been so large that the operator breaks off the continuity of the bone, extension must be employed until the Röntgen photograph shows an adequate formation of callus.

If the cavity contains tumor tissue this must be scraped out carefully, as an insufficient scraping may result in recidivation. During the scraping profuse bleeding may occur which may be difficult to stop. The operation should therefore always be undertaken with Esmarch's method, because in that way the scraping is done most easily and with greatest safety, the danger of bleeding being avoided. The cavity may be filled up with fatty tissue transplanted from the patient himself, as the cavity often heals but very slowly by granulation.

The periosteum must be saved as much as possible. Should the bone be destroyed to such an extent that a total removal of the tumor tissue is impossible, the diseased part of the bone must be resected while all healthy periosteum is preserved.

To prevent any shortening of the bone, either bone may be transplanted or ivory stick inserted. Both proceedings have proved successful; the periosteum has formed callus in abundance after the resection.

It is deplorable that microscopical examination sometimes permits only a probable diagnosis. The interpretation of the preparation in question will always depend on a personal opinion. There has not yet been discovered any test whereby the diagnosis may become absolutely certain either way when the cases are doubtful.

The operator therefore must take upon himself the responsibility of deciding whether to take the usual consequence of a diagnosis of sarcoma, when he is aware of the fact that the original disease may be osteitis fibrosa, or whether the clinical facts of the case justify a conservative treatment—nay, even demand it.

An exarticulatio femoris in young persons is a serious thing indeed,

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and both patient and surgeon will benefit by running the risk of non-radical treatment of a sarcoma if such really be present.

If the case is one of malignant tumor the prognosis is doubtful even after a radical operation, *e.g.*, exarticulatio femoris, and if the disease is benign, the surgeon has unnecessarily made a cripple of his patient, while a conservative treatment would have ensured complete health.

### SUMMARY

Ostitis fibrosa with formation of tumor is not very rare. It occurs most often in young individuals, but may also be found in persons of fifty to sixty.

Trauma appears in many cases to be an etiological factor, although we are unable to explain how it can cause the disease or influence its genesis.

The course of the disease is chronic with comparatively slight symptoms, rheumatic pains, and a slow swelling of the affected bone. The general health is good. Spontaneous fracture or bending of the bones may occur.

The Röntgen photograph is often typical, but sometimes it is impossible to decide whether the diagnosis might not with equal correctness be given as sarcoma.

The treatment is exclusively surgical, all diseased tissue must be carefully removed albeit with an obligation to be as conservative as possible.

When the bone is opened, the cavity is found to be more or less filled with a brownish-red or sometimes yellowish, crumbling tumor tissue. The borderline is, as a rule, sharply drawn, although the same tissue may be found outside the periosteum.

Under the microscope the destruction of the bone is seen to take place in a connective tissue with few cells, *i.e.*, fibrous marrow. Formation of new bone is also seen. The tumor-like tissue is built up partly by very polymorphous cells with numerous and uncommonly large giant-cells, partly from a fibrous tissue with few cells. Mucous tissue with softening and formation of cysts also occurs.

It is sometimes difficult to decide that the diagnosis is not sarcoma.

The disease is benign even when the periosteum is perforated.

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# REGENERATION OF BONE

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## INTRODUCTION

THE transplantation of bone is one of the very important branches of reparative and conservative surgery. The cardinal principles governing the successful transplantation of bone were laid down by Ollier, but there still are divergent views both as to the best technic for bone transplantation and the vital processes by means of which the reproduction of bone takes place.

The reproduction or regeneration of bone is the basic phenomenon upon which a successful transplantation depends, and it is in the hope of shedding more light upon this process that the experiments recorded below were performed by the authors.

A summary of the normal development, growth, and structure of bone along with a brief review of the literature on bone transplantation will be given before proceeding to the results of our work.

There are two types of bone found in man, cartilage bone which develops on a cartilaginous basis, and membrane bone, which develops directly from connective tissue without an intervening cartilaginous stage. The mode of development of cartilage bones only, and not of membrane bones, will be described here, because most of the skeleton is composed of bones of this type and most of the experimental research on transplantation has been done with cartilage bones. Previous experiments have yielded divergent results both as to the fate of the transplanted bone and the regenerative power of its various constituents.

## THE DEVELOPMENT, GROWTH, AND STRUCTURE OF CARTILAGE BONE<sup>1</sup>

A description of the development of one of the long bones will serve as an illustration of the embryonic development of cartilage bones.

The site which is later occupied by a mature, fully developed bone is first filled in by embryonic connective tissue with closely packed cells. This tissue is transformed into cartilage. The cartilage is non-vascular, but is surrounded by a vascular, fibrous membrane, the perichondrium, which develops into periosteum.

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<sup>1</sup>This description is taken in the main from Cunningham's "Text-book of Anatomy," Fourth Edition; and Quain's "Anatomy," vol. ii, Part i, "A Text-book of Microscopic Anatomy," by E. A. Schafer.

Next, two changes occur simultaneously: (1) The cells at the centre of the cartilage become enlarged and flattened and pile up in longitudinal columns radiating from the centre towards the ends, and the matrix becomes hardened by a granular calcareous deposit. (2) The cells of the inner lining of the perichondrium assume a flattened or cuboidal shape and become osteoblasts, constituting the *osteogenic* or *cambium layer*, and form a bony layer on the surface of the cartilage.

Bone is formed from osteoblasts by the deposition of inorganic material about each cell. The osteoblasts are thereby included in small spaces or lacunæ and are then called young bone cells. These cells are not surrounded by a solid calcified wall, but small channels called canaliculi, which arise from the lacunæ, radiate irregularly through the surrounding matrix, and anastomose with canaliculi from neighboring lacunæ. The cells within these spaces also send filamentous processes into these canaliculi, thereby giving the cells a spidery appearance.

The next step is a migration of the subperiosteal vascular and osteoblastic tissue into the centre of the cartilage, followed by an absorption of the calcified cartilage and by formation of marrow spaces. These spaces are filled by jelly-like embryonic marrow and are lined by osteoblasts. This lining of osteoblasts is known as endosteum, but it should be noted that it arises from periosteum. Bone is deposited around these marrow spaces by an advancing line of osteoblasts. The osteoblasts follow and surround the blood-vessels and deposit bone in layers about them. As layer after layer of bone accumulates about the vascular structures, ramifying, communicating trabeculæ of bone are formed, and the large spaces between them become narrowed into intercommunicating channels. While this process is taking place layers of bone are also being deposited beneath the periosteum, but this cortical deposit is penetrated by numerous blood-vessels which communicate with those in the medulla.

At about this time large cells, which are usually multinuclear, appear along the edges of the bone which has been formed. Their action is the absorption of bone and they are termed osteoclasts. In performing their function they excavate hemispherical pits known as foveolæ of Howship.

Bone absorption is necessary for the growth of bone. The absorption occurs most actively in the centre, or medulla, of the bone, though to some extent it also occurs in the cortical portion. By this means the marrow spaces which have, in the meantime, been filled with cancellous bone are reformed as the secondary marrow space. The cortical bone is being removed from the centre, and while this is occurring bone is being deposited in lamellæ upon the outer cortical surface, thus bringing about lateral growth or increase in width. Growth at the ends occurs by an advancing deposit of bone in the growing cartilage.

At about this stage additional centres of ossification develop in each end of the bone. These are called epiphysial centres and are situated between the end, or epiphysis, and the shaft, or diaphysis. The epiphysial line is formed by blood-vessels or vascular loops advancing into the epiphysial carti-



lage and carrying with them endosteum or osteoblasts. This osteogenetic tissue then becomes completely separated from the osseous shaft by a portion of cartilage which remains. This cartilage persists in some places until after puberty, and continually grows, and by being continuously replaced by bone causes the longitudinal growth of bone.

The intercommunicating channels, referred to as arising in the marrow spaces and in the bone deposited by the periosteum, are lined by osteoblasts and deposit concentrically at their periphery successive lamellæ of bone. By this process the channels become reduced to very narrow canals, called Haversian canals. These Haversian canals therefore contain blood-vessels and are lined by osteoblasts. The systems of concentric bone lamellæ are joined together by irregular systems of lamellæ. Upon the surface of the shaft, completely around all these systems, additional concentric lamellæ are deposited beneath the periosteum by the cambium, or osteogenic layer of periosteum.

Eventually the marrow spaces become converted into a central canal filled with mature marrow<sup>2</sup> and containing only a few trabeculæ of bone. Around this central canal is a layer of interlacing bone trabeculæ forming cancellous bone, and all of these trabeculæ are covered completely by a layer or layers of osteoblasts. Outside of this is found the compacta, or cortex, the Haversian systems and lamellæ of which have been described above. The surface is covered by the osteogenic or cambium layer of osteoblasts, which can be considered as lying between the cortex and the fibrous periosteum, or, one might say by way of comparison, that the cambium layer lies between the tree and its bark. It is this similarity which has given rise to the name cambium layer of the periosteum.

The blood supply of the bone is furnished (1) by numerous minute nutrient arteries (mentioned above) which penetrate the cortex from the periosteum through the Haversian canals; (2) by one or more larger nutrient arteries which penetrate the cortex usually at about the centre of the shaft and enter the medullary canal.

The important points to be emphasized are:

(1) All cartilage bone is produced by cells arising from the osteoblasts lining the periosteum and is deposited in preformed cartilage, the latter being absorbed.

(2) The endosteum is formed of osteoblasts which arise from those lining the periosteum, and osteoblasts also extend from the endosteum and the osteoblastic (cambium) layer of the periosteum into the Haversian canals and line them.

(3) Cartilage which is about to be ossified undergoes certain changes, among which is an enlargement and flattening out of its cells, with their arrangement into columns at right angles to the plane of bone growth.

(4) Bone cells (not osteoblasts) are enclosed in bony lacunæ which inter-communicate by means of canaliculi.

<sup>2</sup> The development of marrow will not be discussed, as it has nothing to do with the growth of bone.

(5) None of the bone cells are in immediate contact with blood-vessels or capillaries and their only nourishment must be plasma obtained through the canaliculi.

(6) The above described method of bone growth is known as growth by absorption.

In addition, several other things of importance may be mentioned. Young lacunar cells which have just been formed from osteoblasts may divide and form a very limited amount of bone. When bone develops in this manner immediately in apposition to older bone, the older bone may be absorbed and replaced by this young bone. The method by which bone is absorbed in this instance is not known, but it is not accomplished by the aid of osteoclasts. Apparently it occurs in some direct manner which appears somewhat like solution of the bony structure. This type of bone growth or bone substitution is called creeping replacement.

Most bone, however, arises directly from osteoblasts. *Fully developed bone cells, in the accepted sense of this term, that is, cells within well calcified lacunæ, have never been shown by microscopical observation to have divided and formed new bone.* Undoubtedly most normal bone is formed by the endosteum and cambium layer of the periosteum and only to a less degree by osteoblasts lining the Haversian canals.

#### REVIEW OF LITERATURE

The earliest experimental work bearing upon bone transplantation was done by that great master of bone surgery, Ollier, in 1867. He did not make a histological study of his transplants, nor did he have the aseptic and anti-septic methods of operating that make the work of to-day so sure of successful issue. His conclusions on bone transplantation were all based upon macroscopical observation, and up to the point where microscopic study is necessary they have been found absolutely true. Briefly stated, they are as follows:

1. For the transplantation of bone there is a fundamental difference in the use of autogenous, periosteum-covered grafts, on the one hand, and every other kind of bone material, on the other.

2. Only the former manifests an increase of thickness after a rapid fibrovascular connection with its bed, and it is the increase of thickness which is a sure indication of continued vitality of the transplanted bone.

A true graft of bone (*i.e.*, a graft that retains its vitality) is possible only after transplantation of living, autogenous periosteum-covered bone, and this is in virtue of its living periosteal covering. This latter, after transplantation, remains alive, *and thereby maintains the life of the transplanted bone.* It is, therefore, the most important factor in bone transplantation.

3. Every other kind of bone when transplanted dies, if it is not already dead at the time of its implantation. All of these varieties of transplants become foreign bodies, and either remain intact and encapsulated at the site of implantation, or they are resorbed, the latter process often being hastened by the blood-vessels which penetrate into them. If such material is im-

planted in a bed that is itself bone-producing, it is possible, under favorable condition, for it to be replaced by new bone formed from this bony bed.

4. Where it is desirable to restore bony continuity after the removal or destruction of bone, one must make use of living, autogenous, periosteum-covered bone grafts.

These conclusions were accepted and remained classical until the work of Radzimowsky, 1881, and Bonome, 1885. Both these experimenters contended in contradistinction to Ollier that all transplanted bone tissue dies even when it is autogenous and covered by living periosteum, but that the periosteum lives. As proof of their contention they instanced the death of the bone cells as shown by the change of the latter in morphology and staining qualities.

Radzimowsky demonstrated in the cranial and long bones of birds and mammals that bony union between bone fragments and adjacent bony tissue easily takes place irrespective of whether the periosteum is preserved or not, over such fragments. Such bony union, however, may be considered no evidence of enduring life in the fragments of bone, and further, the presence of blood-vessels in such fragments is no evidence of life therein, inasmuch as dead bone may also be permeated by blood-vessels from its vicinity. Microscopic examination of such bone fragments showed that they were dead, for the bone cells were dead. On the other hand, he demonstrated that the periosteum lived and produced new bone. Therefore, he concluded that when living periosteum-covered bone is transplanted, the bone tissue proper dies, but the periosteum lives and produces new bone that is deposited not only on to the surface of the transplanted dead bone, but also into its lacunæ and enlarged Haversian canals.

Bonome, working with rats, reached conclusions similar to those of Radzimowsky, and also showed that when fracture of the bone occurred the bone in the immediate vicinity died, as was shown by the staining qualities of the bone cells. As to the ultimate fate of the dead bone he concluded that this is resorbed and replaced by new bone which is formed from the osteogenetic layer of the periosteum.

The work of these two experimenters established, with the aid of microscopic study, the first great advance after the pioneer investigations.

No new advances or contributions to the subject of bone transplantation were made until Barth, 1893, reported the results of his experiments. He likewise found that when autogenous, living, periosteum-covered bone is transplanted the bone tissue dies, and in addition he makes the important assertion that he could not convince himself that the periosteum or marrow fared any better than the bone tissue proper. He deduced from his experiments, which were performed on the skull, that the transplanted periosteum also died, and was replaced by the growth of periosteum from adjacent bone which extends over and covered the graft. He concluded, therefore, that inasmuch as all the parts of a living periosteum-covered bone graft died, it is immaterial whether we use, for transplantation purposes, bone covered or uncovered by periosteum, or decalcified or macerated bone. He thought

that the transplant was a sort of splint, to be gradually replaced by new bone formed from the surrounding bony tissue. Briefly stated, the conclusions of Barth were as follows:

1. Fragments of any kind of bone like other foreign bodies can be implanted into the living tissues.
2. All varieties of bone material are similar in the process of their implantation and of their bony replacement.
3. When living bone with periosteum is transplanted, all of its integral parts die.
4. Therefore, all varieties of bony substance are foreign bodies at the outset, or become so, and are *gradually replaced by new formed bone from the adjacent bone-producing tissue.*

These conclusions, radically different as they were from those of Ollier and his followers, were accepted, and for the next decade surgeons gave up altogether bone grafting and used macerated or decalcified bone or other foreign material to fill gaps in the continuity of the skeletal system. The lack of success of these procedures was brought out in the German surgical congress of 1902, when the subject of bone transplantation was brought up for discussion. It was the general opinion at this meeting that though the experimental conclusions of Barth might be true, the same did not hold in practice. The opinion expressed seemed to be unanimous—that the best results were obtained when living, autogenous, periosteum-covered transplants were used. Even Barth had to concede this in the light of his subsequent experience.

In order to gain more information on the subject Axhausen took up the work anew, and by his experiments and histological examinations placed the whole subject on a firm basis. His conclusions were as follows:

1. The conclusions of Barth as to the relative equal value of all varieties of bony material for transplantation cannot be upheld.
2. The first law of Ollier, namely, that there is a fundamental difference, as regards transplantation, between the use of living, autogenous periosteum-covered bone, and every other kind of material, is true in other animals as well as in the human subject.
3. The difference lies not, as Ollier thought, in the survival of the life of the transplanted bone tissue proper, for most of this dies, only a few cells persisting, and is replaced by new bone, but exists in the periosteum which survives.
4. This surviving periosteum produces the new bone. When the transplantation is made into a bone-producing bed the new bone formation from the periosteum is not marked, for this bed is alone sufficiently able to fill the gap in its substance. But in the case of transplantation into a defect of the long bones this periosteal new bone formation, together with that from the marrow, are the only means for filling the gap.
5. The survival of the bone-producing periosteum established a rapid and intimate vascular connection between the transplant and its bed, and in virtue of its bone resorbing and bone forming power this surviving periosteum

forms an intimate connection with the underlying transplanted dead bone. This is in marked difference to the loose fixation of the transplant in the tissues when bone uncovered by periosteum is used.

6. The survival of the marrow has no dependence upon whether the graft is covered or uncovered by periosteum.

These experimental conclusions were in accord with the empirical ones reached by practical surgeons, and since these classical labors of Axhausen the surgical world has accepted, until recently, the fundamental law of Ollier, namely, that for a real bone graft we must use an autogenous portion of bone covered by living periosteum.

The truth of this law of Ollier has been disputed by William MacEwen in a monograph entitled "The Growth of Bone," published in 1912.

MacEwen claims that periosteum is merely a limiting membrane, which has not the capacity to form bone, but serves only to confine the bone within bounds and prevents its overproduction. He believes that bone has the power to reproduce itself, if it receives proper blood supply, and is the only tissue from which new bone can grow.

There are two important criticisms which can be made of MacEwen's work:

1. In spite of his large number of bone transplantation experiments there is an almost complete absence of microscopical study of the grafts. Therefore, evidence, which is only revealed by the microscope, that the *bone cells* of the transplant are alive and that regeneration has originated from them and them alone, is lacking.

2. He concludes that transplanted bone is alive if it has contiguous connective tissue adherent to it and gives with the X-ray a shadow almost as dense as that of the original living bone. This, however, has been disproved by Küttner, who showed that this occurred in homogeneous human transplants of large portions of bone, such as the head and upper third of the femur, and still on microscopical examination all of the bone cells were dead and no osseous regeneration of any sort had taken place from the transplant.

Since MacEwen's monograph several important contributions have appeared, in the main contradicting his conclusions.

Mayer and Wehner, from a carefully planned series of experiments of transplants of periosteum, subperiosteal resections, cap implantations, and bone transplants, conclude that all of the results "combine to emphasize the osteogenetic function of the specific osteoblastic cells (of periosteum, endosteum, and lining Haversian canals) and the inability of the adult bone cells to form new osseous growth.

Their cap experiments are especially conclusive.

They note the part played by the osteoblasts lining the Haversian canals in regeneration of bone, but do not assign to these cells the importance they probably deserve. They demonstrate, however, that it is the outgrowth of these cells from the Haversian canals which forms new bone about **free** transplants of cortex devoid of endosteum and periosteum, and that this is

not due to the metaplasia of the surrounding connective tissue according to Baschkirzew and Petrow.

Mayer and Wehner also have shown that in the replacement of old bone by new bone the process described by Marchand and Barth as "creeping replacement" is of equal, if not greater, importance than the well recognized one of absorption and substitution.

Phemister's investigation adds additional experimental evidence to that of Mayer and Wehner. In some very well selected experiments he demonstrated that in artificial or acquired fracture in the middle of a transplant of a portion of the entire shaft of a long bone, new growth of bone occurs at the fracture, whereas the bone between this fracture and the ends of the transplant (which are in contact with the original shaft) is dead. This new bone arises mainly from endosteum and periosteum. Phemister believes, however, that a few bone cells of the compacta do proliferate and form new bone. A careful perusal of his protocols does not reveal any definite evidence of this. It would seem that here he is dealing with osteoblasts of the Haversian canals as noted by Mayer and Wehner and not with bone cells. The healing of these fractures in the transplant, of course, completely disproves the idea that bone reproduction occurs only through "osteconductivity," which was held originally by Barth and at present by Murphy and by Davis and Hunnicutt.

Smith also reached the conclusions from his experiments that mature bone cells are end products and that osteogenesis is limited to the osteoblasts.

#### OUTLINE OF EXPERIMENTS

The object of the experiments to be reported was to determine the fate of the various component tissues which make up bone, when these were transplanted either singly or in different combinations, and also to find out under what circumstances these transplants produced new bone, and which element or elements were capable of generating bone.

The following experiments were performed on twenty-two full-grown cats; the transplants were autogenous, and the material was taken from the tibia. In all cases primary union was secured at the wound over the tibia and at the site of transplantation. A few of the transplants were placed on the surface of, and within the substance of, the spleen, or subcutaneously. Most of them, however, were placed upon the costal cartilages, after these were either scraped bare of perichondrium or else after removing a wedge from the cartilage or cutting away its outer half. An attempt was made at first to lift up the perichondrium and insert the transplant between it and the cartilage. The perichondrium was found so intimately bound down that it was impossible to do this without tearing it severely, so this method had to be abandoned. The transplants were held in place by two black silk ligatures which were placed at the two ends and around the cartilage. With a sharp, full curved needle, the ligature could be passed around the cartilage without entering the pleural cavity. In order to determine the nature of the material transplanted, pieces of tissue were removed from each transplant as soon

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as it was secured, placed in 10 per cent. formalin and examined microscopically. A series of control experiments was performed by injuring the cartilage in a number of ways, in order to determine if any impetus or tendency to form osseous tissue could be given cartilage by manipulations similar to those necessary in using it as a site for transplantation.

Cartilage was chosen as the site of most of these experiments for several reasons. It has been shown that tissues differ in the degree of their capacity for serving as a satisfactory medium or soil for the implantation upon them of other types of tissue. Certain structures, such as the spleen, serve in this capacity very poorly, and in fact the spleen seems to have a destructive action on grafts placed within it. Subcutaneous or intramuscular situations have been the ones most often and most successfully used in transplantation experiments. There are also certain special affinities which exist between tissues, as, for instance, with testes and ovaries. Stockard has shown that these organs serve well as a base for transplantation of grafts taken from each other, whereas grafts from either do very poorly on other tissues. Consequently because of the intimate relationship which exists between bone and cartilage, both during the process of growth and in the stage of full development, it was thought that it would be interesting to note in what manner cartilage would serve as a base for transplants of different elements of fully developed bone, and whether it still retained its ability to readjust its own elements in the peculiar manner which occurs in the laying down and growth of enchondral bone.

Also one of the requisites for the successful transplantation of tissue is that the graft should be rapidly vascularized. For this reason transplants are usually made subcutaneously, intramuscularly, or into parenchymatous organs. Cartilage, however, is nonvascular, and it was thought that transplantations upon this would prove a severe test of the regenerating power of the transplanted bone, which could not get its vascular supply from the cartilage but would have to obtain it from only one side which would lie in contact with the connective tissue. In addition, because of the freedom of the cartilage from blood-vessels, if the bone graft did grow in the direction of the cartilage, it would furnish a good opportunity to observe just which element or elements of the graft proliferated.

### MATERIAL AND METHODS

The material for the transplants was obtained in the following manner:

The anterior surface of the right tibia was exposed and all tendons and muscular attachments cut away, care being taken not to injure the periosteum. The periosteum was obtained from the entire surface exposed, by outlining a long quadrilateral piece with the scalpel, then lifting it up at one end with a fine forceps, and teasing it away from the bone with the handle of the scalpel. It always peeled away very easily and no macroscopic bone came away with it. The question as to the nature of the cambium (osteogenetic) layer, or portion of this layer, which was lifted off with the periosteum is discussed later. Next, with a gouge chisel, thin layers of cortex, from 1 to 3

mm. thick, were removed, care being taken not to enter the medullary cavity. It was assumed that a portion at least of the cambium layer remained upon the cortex, and for convenience the pieces of the cortex taken in this manner are called cortex plus cambium. To obtain pieces of cortex alone, the surface was first thoroughly scraped with a heavy scalpel, and then the pieces were removed with a gouge. Cortex covered by periosteum was obtained by outlining with a scalpel an area of periosteum about  $.5 \times 1$  cm. Then the cortex beneath this, with the periosteum still adherent, was removed with a gouge chisel. Care was taken not to enter the medullary cavity so as not to include endosteum.

The transplants called cortex plus endosteum are simply pieces of cortex, where the gouge was allowed to enter the medullary cavity and remove in addition a portion of the medulla.

Portions of these different types of transplants which served us as controls showed uniform microscopical pictures, and need not be described repeatedly under the different experiments, but can be taken up collectively here.

*Periosteum Control-Serial Sections.*—Sections are made up of the usual connective and fibrous tissue, but along the edge corresponding to the cambium layer, the connective tissue is rather compact and the cells are arranged parallel to the surface. A portion of the surface which faced the cortex is lined by cells which resemble the adjacent connective-tissue cells, but at the same time present an appearance somewhat similar to endothelium. In other places, these surface cells are slightly larger and more rounded and seem to differentiate themselves from the connective-tissue cells immediately beneath. This special layer of cells which constitutes the cambium layer is found only over portions of the surface, occupying about half of its extent. The remainder of the surface is made up of bare connective tissue.

*Cortex Control.*—This is made up of typical dense cortical bone. The Haversian canals are small, most of them the size of capillaries. (Much smaller than in any of the transplants described below.) The edges are everywhere devoid of connective-tissue cells or any cells similar to the cambium layer of the periosteum described above. Also the edge to which the periosteum was attached, and where the cambium was scraped away, is slightly uneven, as though the surface of the bone had been scraped away.

*Cortex plus Cambium Control.*—The edge from which the periosteum has been removed is smooth, and in places the cortex is bare, whereas in other places there is adherent to the cortex a small amount of loose areolar tissue. At these latter places, the cells immediately next to the cortex are drawn out and flattened, and have somewhat the appearance of endothelial cells, and are similar to those of the cambium layer found lining the periosteum described above. Immediately beneath this layer of cells the superficial cortex does not exactly resemble the deeper portions, staining somewhat differently, taking a slight diffuse hæmatoxylin stain, and its lacunar cells are closer together. The nuclei of the lacunar cells immediately beneath the cambium layer are drawn out and stained densely, and are identical with



those of the cambium; whereas the nuclei of cells further away are round or oval in outline. A number of nutrient vessels spring from the cambium layer and enter the cortex at an angle, and their canals are sparsely lined by the same type of cells which are immediately adjacent to the cortex and which form the cambium layer.

*Cortex plus Periosteum Control.*—Shows cortex covered by periosteum, these structures being identical with those described above. The cambium or osteogenic layer is similar to that described under cortex plus cambium, only it is thicker and made up of more of the same type of cells. In one series of sections, whereas the lacunar cells immediately beneath the cambium are similar to the cells of the cambium layer, after a distance of one or two cells into the cortex the lacunar spaces are larger and their cells are also larger and more oval and more vesicular, so that these cells, taken altogether, have the appearance of young lacunar cells. (These are somewhat similar to those seen in the new-formed bone in the transplants to be described below.)

*Cortex plus Cambium plus Endosteum Control.*—These transplants are made up of cortex and cambium identical with those described above, and in addition a portion of the medulla of the bone made up of marrow spaces filled with marrow and subdivided by trabeculae of bone. The marrow spaces are lined by flattened cells somewhat endothelial in type, identical with those forming the cambium layer. These cells are seen dipping down into the Haversian canals and lining them.

## GENERAL DISCUSSION OF RESULTS

*Experiments with Transplants of Periosteum.*—Twenty-five periosteal transplants upon costal cartilage were examined at periods from 7 to 389 days. All showed active bone formation. One subcutaneous transplant after 77 days showed bone, one on the surface of the spleen showed bone after 82 days, but one in the depth of the spleen for the same period showed nothing but a scar. This is in accordance with the experiments of others with different tissues, and shows the tendency of spleen to absorb foreign tissues.

The process of growth of bone from these periosteal transplants has therefore been studied at such intervals that a definite conception may be formed of the manner of its occurrence.

In the youngest transplants (7 days) there is found in the midst of granulation tissue, an extremely young osteoid tissue which is in contact with the osteogenic layer of the periosteum. The next stage is found after about 28 days, where young bone is seen as branching columns, covered by a continuous line of osteoblasts. Here the lacunar cells are just about formed and are large, with large, oval vesicular nuclei. From this stage on, there occurs in older transplants well formed bone, with all of the characteristics of bone. The lacunae are fully developed and are grouped concentrically around Haversian canals, and also irregularly disposed between these concentric systems. At a distance from the periosteum instead of canals are found larger spaces which are irregular in shape and are first filled with blood-vessels and delicate granulation tissue, and lined by osteoblasts, and

are later occupied by genuine hæmatopoietic marrow (sometimes admixed with fatty marrow), composed of myeloblasts, myelocytes, megalokaryocytes, megaloblasts, etc. When this new-formed bone is in contact with cartilage it almost invariably invades it in the same manner as enchondral bone invades its cartilaginous matrix, in the normal development of bone, *i.e.*, in the manner described in the protocols as epiphyseal line formation. It would seem from this that cartilage is an excellent medium to accommodate the growth of bone, and that even though it is nonvascular, bone will grow into it and carry its nourishment along with it.

The older the transplants the more calcified they are and the more the lacunar cells assume the appearance of adult bone cells, their spaces and nuclei being smaller and more elongated, and the latter also staining darker.

There is one observation of importance concerning the young lacunar cells which are not yet in a bony matrix but are away from any layer of osteoblasts. The same process of amitotic division and growth is found as was described by Mayer and Wehner. It seems definite that these young cells proliferate in this manner and so account for some of the production of bone. They are found crowded together in areas, in the midst of well developed bone. Here the lacunar spaces are somewhat larger than elsewhere and in some of the areas are in the midst of a matrix which partakes of the properties of both bone and cartilage, for with the hæmatoxylin and eosin stain it has the appearance of bone but stains bluish, like cartilage. Nuclei which are much elongated, indented, or figure-eight in shape, are relatively common in these lacunar spaces, but two nuclei in a single space are seldom seen. Young lacunar cells which lie close to one another or are barely separated by a very thin partition and which appear to have just divided are relatively frequent. Therefore, taking all these facts into consideration, it must be recognized that this is one manner of bone growth. This growth of bone is from young, immature lacunar cells which have just developed from osteoblasts and whose lacunæ are not yet formed by calcified osseous material. It is this type of growth which occurs in bone transplants and in the development of bone and causes the "creeping replacement" of Marchand and Barth. We have never observed this or any other manner of growth proceeding from adult bone cells.

The source of origin of the hæmatopoietic marrow and its method of development is another point of interest and needs further study for its elucidation. The transition has gradually progressed from (1) Haversian canal containing a blood-vessel with a wall formed of a single layer of endothelium and a layer of osteoblasts between the vessel and bony wall, (2) a larger space containing in addition delicate connective tissue, and, finally, to (3) a completely developed marrow. Whether this process of the development of marrow has to do with the histocyte or the endothelium or the osteoblasts is a problem for further investigation.

The manner in which cartilage serves as a medium for bone is remarkable in that it is identical with the embryologic development of bone in cartilage. The reason why the cartilage cells arrange themselves in columns

at right angles to the line of advancing bone has never been explained. This method might serve as a means to attack the problem.

In the older transplants bone absorption is taking place as well as bone growth, for osteoclasts are found at various places along the periphery of the new bone and also of the marrow spaces.

Many of these transplants could not be identified macroscopically as bone, and certainly most of them would not have thrown a shadow with the X-ray. Therefore, it follows that in all experiments of this kind the end result must be carefully controlled by microscopical examination, and where this is not done the conclusions arrived at are based on incomplete evidence.

It is inconceivable that after the careful microscopic examination with negative findings of control pieces of periosteum any bone cells could have been adherent to these transplants. Therefore, the conclusion must be drawn that the bone grew from osteoblasts which form the osteogenic layer of the periosteum and did not arise from bone cells. The fact that the control pieces of periosteum were lined only in places by osteoblasts and not over their entire extent explains why bone did not always spring from the entire surface of the periosteum.

*Transplants* (of Cortex minus Cambium, Cortex plus Cambium, Cortex plus Cambium plus Endosteum, Cortex plus Periosteum).—Although some of these transplants were in place in the cats as long as 250 days, and were comparatively small pieces, not more than  $2 \times 3 \times 10$  mm., none were completely absorbed in that time. Many of them which showed microscopically either well formed bone or growth of bone were too small to have cast a shadow with the X-ray.

The bone or cortex of all the different types of transplants showed the same process, and the nature of this would explain the discordant results which have been reported about transplantations and the osteogenic power of bone.

The transplants removed after the shorter intervals show that most, but not all, of the bone cells are dead and therefore unstained. Those cells which are stained, however, are situated near sources of nourishment (by diffusion), such as the edge of the transplant, the periosteum, or Haversian canals. After a somewhat longer interval there are fewer stained bone cells, but even these have small, irregular, darkly-stained nuclei. In the oldest transplants the tracing of these cells is interfered with by other processes which are going on, but always a certain number of these cells are seen, which are undoubtedly the original cells transplanted, and can be differentiated from the young bone cells present. Therefore it must be as Axhausen contended that, whereas many, if not most, of the bone cells transplanted die, some persist and live. Although carefully examined, none of these adult cells which persist were ever found in any place in the transplant either dividing or giving rise to new bone.

The blood-vessels in most of the Haversian canals evidently, very soon after transplantation, join with surrounding blood-vessels, for their walls are made up of living cells which stain normally, and they contain blood-

cells which are normally stained and alive. The cells of the vessel walls must have been kept alive in the meantime by the blood which was in them or by plasma which diffused in from the tissue next to the transplant. Some canals are empty or contain abnormally-stained blood-vessels and blood-cells which are dead. Very soon after transplantation the Haversian canals enlarge and are found lined by osteoblasts, though a few osteoclasts are also found at this stage. But the absorption of the bone around the canals seems to occur largely in a direct manner and not by the aid of the osteoclasts.

Almost simultaneously with the enlargement of these canals is found a formation at their periphery of a ring of young bone composed of young bone cells. Soon this ring is several cells thick and is found progressing into the bone originally transplanted, the canal becomes progressively larger. These young cells then proceed more or less irregularly, and, where the canal is near the surface of the transplant, they gain the surface and spread out over it.

This process of growth from the osteoblasts lining the Haversian canals is a very active one and is seen replacing all, or almost all, of the bony transplants and spreading out beyond. These young lacunar cells are also seen dividing just as they were in the bone formed from periosteal transplants. As there are no osteoclasts between them and the original bone which is being absorbed, the absorption must be accomplished by them, perhaps through a biochemical action, and they replace the old bone by "creeping replacement." It is conceivable that they might slip into the empty lacunar spaces of the original bone, but this was never observed.

The transplant, cortex without periosteum, removed after an interval of 53 days (see Fig. 7) is an excellent illustration of this type of bone growth. It also shows that bone cells of the original cortex transplanted, even though they are well nourished by being in apposition with living granulation tissue, do not grow, whereas osteoblasts lining the Haversian canals do.

In order to follow these two types of cells carefully, full grown and not young cats were used in these experiments so as to be able to observe the behavior of adult bone cells and not confuse the study with young bone. Consequently the results of this study carry with them the firm conviction that adult, differentiated bone cells are sufficiently specialized, in the same manner that nerve cells are, to be unable to reproduce themselves.

In the oldest transplants practically none of the original bone is left, but its place is taken by this new formed bone. Osteoclasts are also found here and there along the edges of the transplant, and at the periphery of enlarged Haversian canals.

As the Haversian canals enlarge they first form spaces, thinning out the intervening bone into trabeculae, and later forming larger marrow spaces filled with hæmatopoietic marrow.

The new bone arising from the Haversian canals grows from the edges of the cortex transplant just as vigorously as does that arising from the cambium layer of periosteal transplants, and invades cartilage in the same manner with epiphysial line formation.



FIG. 1.—Control: Regeneration of cartilage only, after slivers of cartilage were lifted up and tied back again in place ( $\times 60$ ).

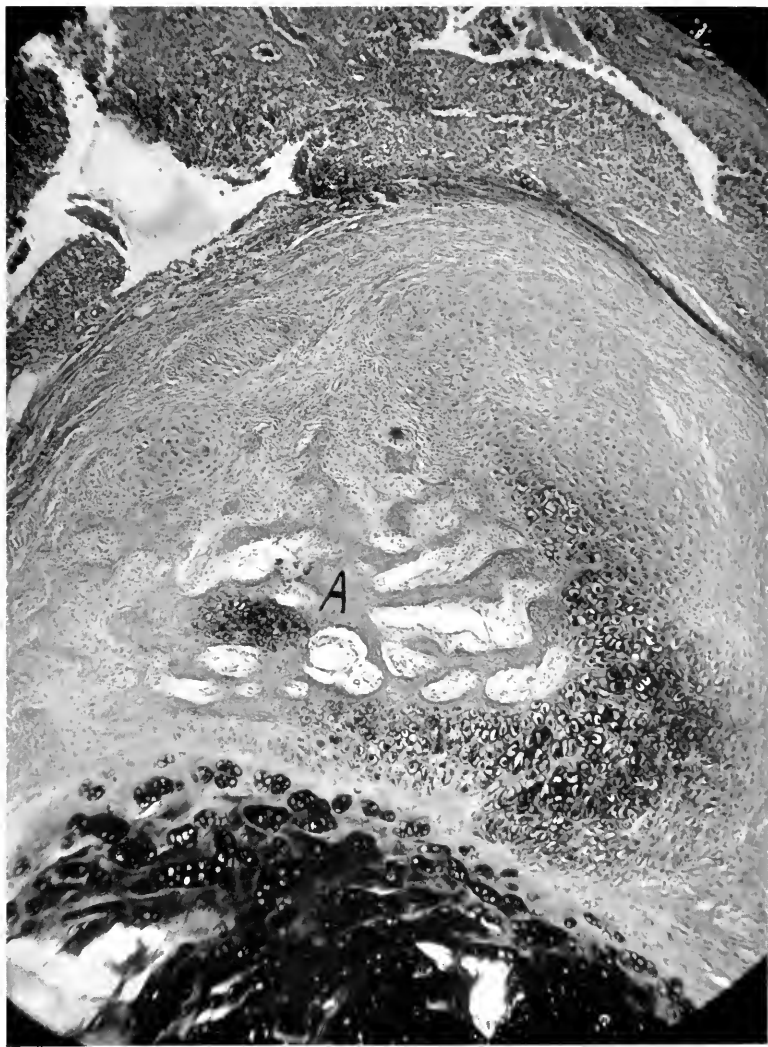


FIG. 2.—26-day transplant of periosteum upon the surface of cartilage denuded of perichondrium; showing the growth of osteoid tissue from the periosteum (A) ( $\times 60$ ).



FIG. 3.—53-day transplant of periosteum upon surface of cartilage denuded of perichondrium, showing growth of young bone from the periosteum (A) ( $\times 60$ ).



FIG. 4.—245-day transplant of periosteum upon surface of cartilage denuded of perichondrium; showing bone (A) with epiphyseal line formation (B) growing from periosteum ( $\times 40$ ).



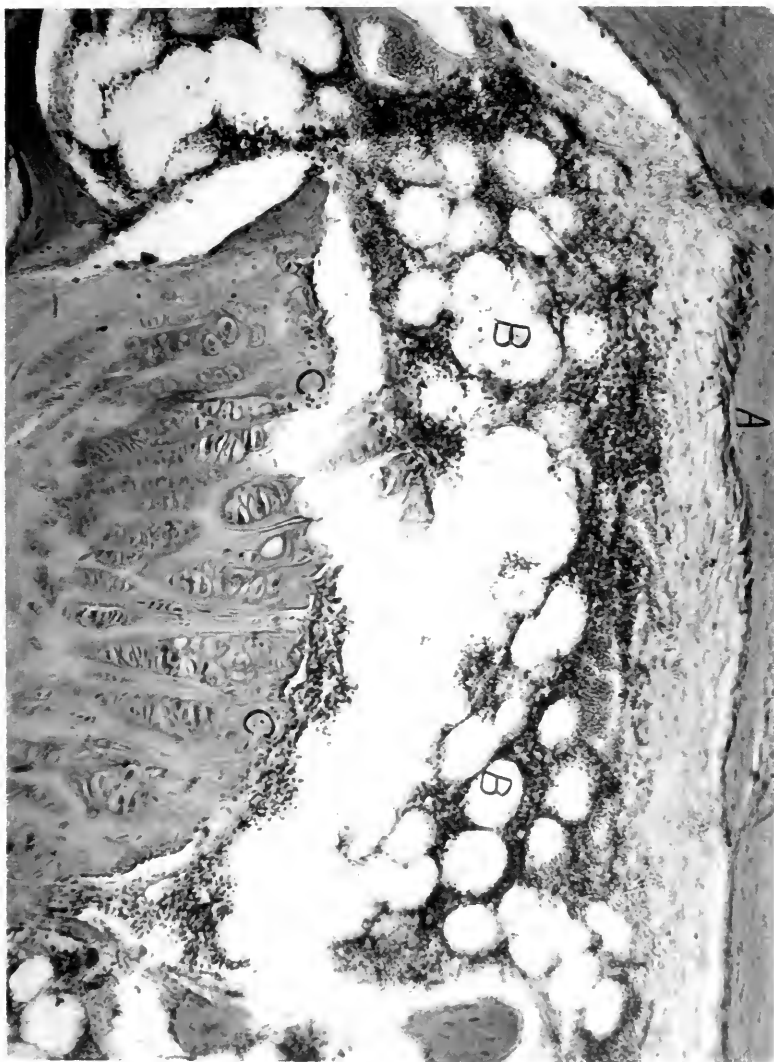


FIG. 5.—High power of Fig. 4. A, bone; B, marrow; C, epiphyseal line formation ( $\times 100$ ).

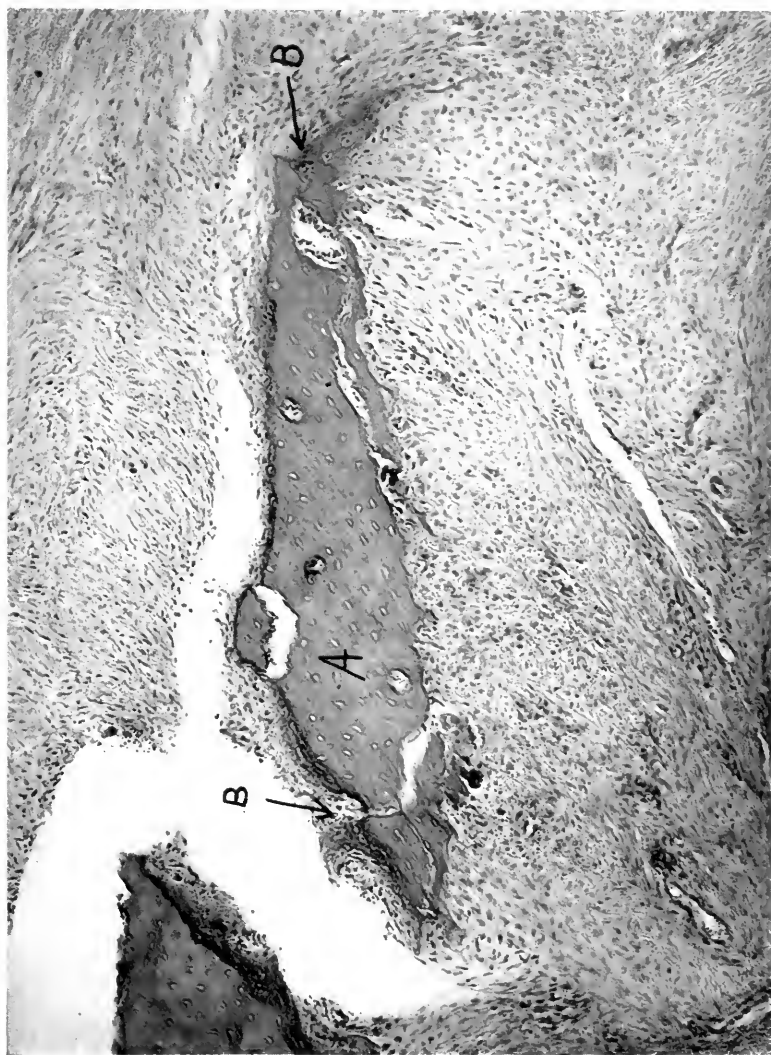


FIG. 6.—28-day transplant of bone cortex without periosteum. Transplant is upon surface of cartilage, but the cartilage is not shown in the photograph. The transplanted bone is dead (A) and the lacunar spaces are empty. There is growth of bone around some of the Haversian canals (B) ( $\times 60$ ).



FIG. 7.—215-day transplant of bone cortex without periosteum. Transplant is upon surface of cartilage. There is proliferation of bone from around Haversian canals (A) and spreading out upon the surface of the bone transplant (B) ( $\times 600$ ).

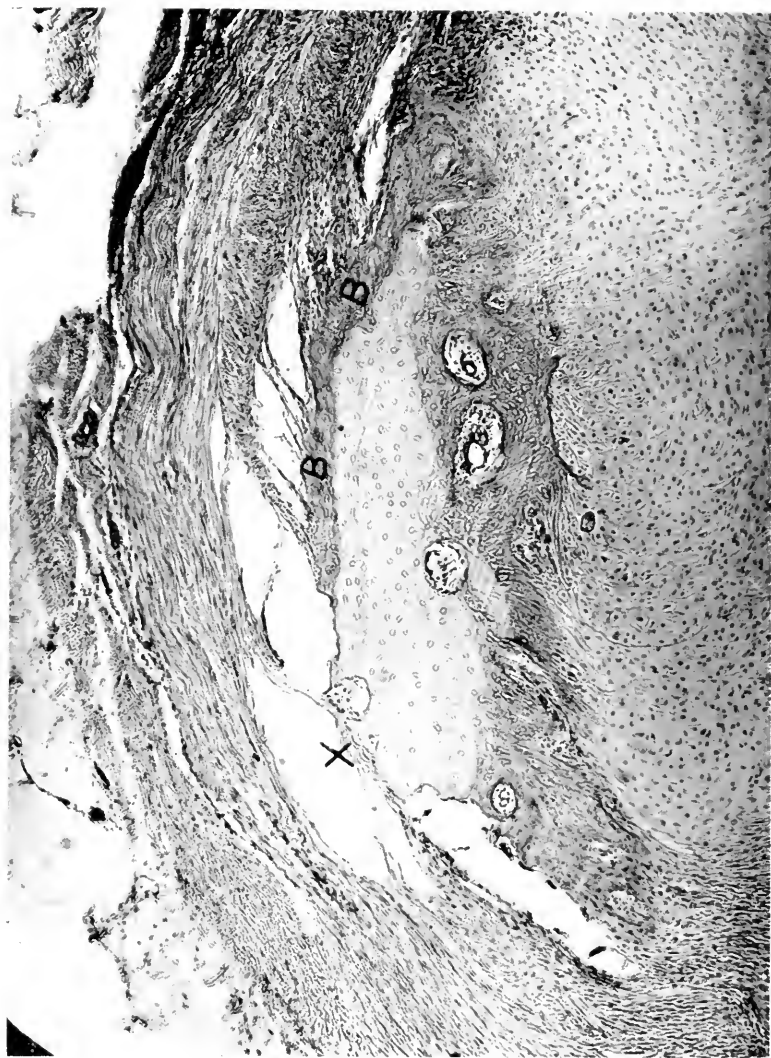


FIG. 8.—53-day transplant, same as Fig. 7 and showing the same. At X, where there is no proliferation of bone, the surface of the transplant of bone is adherent to the surrounding connective tissue just as it is at B; where there is proliferation of bone. Consequently, if the growth of bone occurred from adult bone cells the conditions of growth, such as vascular nourishment, are as good at X as at B. Since growth has not occurred at X, this section would indicate that adult bone cells are incapable of growth and proliferation (X 50).



FIG. 9.—High power of same as Fig. 8, showing double nuclei in a young lacunar cell (A) ( $\times 200$ ).



FIG. 10. —45-day transplant of cortex plus periosteum upon surface of cartilage denuded of perichondrium. This shows proliferation of bone (*B*) between periosteum (*D*) and an area of dead transplanted bone (*E*). There are present other areas of dead bone and also bone proliferation around Haversian canals (*P*) ( $\times 100$ ).

Those transplants which are covered by periosteum show a growth of bone between it and the cortex which is more advanced than that proceeding from the Haversian canals and so undoubtedly is formed from the intact cambium layer.

Where the transplants are made up of cortex plus cambium, the growth from the Haversian canals, which breaks through on to the surface, is as active as the growth from the cambium layer.

The subcutaneous transplants show this same group of processes. One series of transplants into the spleen shows also the same findings, but another series left for even a longer interval showed less growth of the transplants, but persistence of them. This must be attributed to either a difference in action of similar transplants in different animals, or to a difference in the action of the spleen in different animals.

The few transplants which included endosteum, though not enough to allow any definite conclusions to be formed, showed an even greater growth from the endosteum than from any other transplants, even including periosteum.

It must also be noted that the transplants of cortex plus periosteum retained their vitality longer than those devoid of periosteum and more of their bone cells persisted and less of their bone was absorbed.

To summarize: Especial emphasis must be placed on the activity of the osteoblasts lining the Haversian canals in forming new bone. These cells are always transplanted along with bone and consequently play a considerable rôle in bone formation under these circumstances. This point has been noted by Mayer and Wehner, but its significance and importance has not yet been fully emphasized. Many workers have reported new growth of bone as occurring from freely transplanted pieces of cortical bone. As these pieces have been devoid of periosteum, cambium layer, and endosteum, the new bone production has been considered as arising from the bone cells. Most of these specimens have not been carefully examined microscopically, and consequently the exact source of osteogenesis was not determined.

We believe, therefore, that it has never been shown conclusively that an adult bone cell can divide and produce new bone cells and new bone—and by an adult bone cell is meant a fully developed bone cell within a lacuna formed of completely calcified osseous tissue. The adult bone cell must be carefully differentiated from the osteoblast within a lacuna surrounded by uncalcified matrix. This latter is not a bone cell in the accurate sense of the term, but has frequently been erroneously so called. This young cell is the active one in creeping replacement. Mayer and Wehner indicate that they have also reached this conclusion.

The study of this point in the literature is difficult because of a confusion arising from a loose use of the term bone cell. An instance of this can be noticed in the excellent recent article by Phemister, where he describes bone formation from the osteoblasts lining the Haversian canals

and apparently considers the osteoblasts to be bone cells. Of course, in regenerating bone where replacement of the osseous tissue is occurring by both lacunar absorption and substitution and by creeping replacement, the young bone cells are in apposition with the old cells and differentiation is at times difficult. Still, we believe that this differentiation is possible by careful microscopical study. The identification of periosteum, endosteum, and osteoblasts lining Haversian canals, and the bone which arises from them, is in reality easily accomplished. It has been definitely proved that osteoblasts in all of these locations can produce bone and that those in the Haversian canals can assume considerable osteoproduative activity when they are properly nourished. This accounts for their activity in transplants of small fragments of bone where the revascularization of the Haversian canals takes place rapidly and the lining osteoblasts are kept alive till this occurs by plasma from surrounding tissues. In large transplants more time is required to establish a new source of nourishment for these particular osteoblasts and their osteoproduativity is correspondingly reduced. Nevertheless, in transplants of cortex devoid of periosteum and endosteum these cells are responsible for whatever new intrinsic bone formation takes place. It naturally follows that any factor which aids in the nourishment of these cells also aids bone growth in the transplant. Since the periosteum covering the cortex is of material assistance in this nourishment, it can readily be seen how transplants of cortex covered by intact living periosteum are more probable of success, aside from the osteogenic function of the cambium layer, than are transplants devoid of periosteum.

#### CONCLUSIONS

1. Periosteum, devoid of adherent bone cells when transplanted into foreign tissues, produces bone.
2. Endosteum and osteoblasts lining Haversian canals in bone transplants produce bone very actively.
3. The cambium layer when adherent to transplanted cortex produces bone.
4. Some bone cells in the transplants are able to persist for almost a year, but most of the bone is absorbed.
5. Fully developed adult bone cells, although they may remain alive for a considerable time, do not reproduce themselves and form bone.
6. Very young lacunar cells (frequently erroneously called bone cells) can reproduce themselves and form bone.
7. Transplanted bone is absorbed not only by osteoclasts, but also by a direct action (biochemical?) of growing, young bone, and the transplanted bone is replaced either by a creeping forward of the new bone or a gradual extension or expansion of the new bone into the transplant.
8. Marrow spaces and hæmatopoietic marrow are formed in the bone which develops from transplanted periosteum. The source of these hæmatopoietic cells was not determined.



## REGENERATION OF BONE

9. Bone, when it grows into cartilage, does so in the same manner characteristic of the normal embryonic development of enchondral bone, including also epiphysial line formation.

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## TRAUMATIC LUXATION OF THE SACRO-ILIAC SYMPHYSIS WITHOUT FRACTURE OF THE PELVIS

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WHILE J. W. M., age 50, height 5 feet 9½ inches, native of San Francisco, weight 206 pounds, master mechanic at the Western Sugar Refinery, was working at the bottom of an elevator shaft, July 26, 1916, a heavy freight elevator descended. He attempted to escape, but too late; while on hands and knees the elevator came down upon the small of the back and hips, forcing him down on a concrete floor, where he was held fast for a brief interval. He entered the hospital 11.15 A.M., in profound shock, temperature 97, pulse 60, suffering great pain in the pelvis. The left thigh was flexed upon the pelvis, adducted and rotated inward, the leg was flexed upon the thigh. He was unable to void urine normally until 4 P.M. of the next day. Examination by X-ray showed luxation of the head of the left femur upward and backward upon the ilium. In the radiogram a portion of the sacro-iliac symphysis showed and bore evidence of injury to that joint. On account of shock no operative procedure was undertaken until July 27th, when, under anæsthesia, the luxation at the hip-joint was reduced. Attempts at reduction by Bigelow's method failed, probably due to luxation of the innominate bone. The pelvis was firmly fastened to the table and strong traction applied to the limb in full extension, and in a line parallel with the axis of the body, when the head of the femur was felt to slip into the acetabulum. The left lower limb now assumed the position of marked external rotation, with the toes inverted.

Further examination by radiography showed wide separation both at the sacro-iliac symphysis and at the symphysis pubis, indicating upward and outward luxation of the left innominate bone. August 3d this was reduced in the following manner:

Patient was anæsthetized and fastened to a Hawley fracture table; a yarn rope was passed over the crest of the left ilium from before backward, one end being brought down behind the body and the other in front. To this two guy lines were fastened, one carried behind the pelvis and the other in front and held at right angles to the axis of the body, by an assistant. They were to prevent the yarn rope from slipping over the iliac crest during traction. Steady and continuous traction was then applied to the crest of the ilium by means of the yarn rope. When it was thought that the bone had been restored to its normal position a radiogram was taken, while traction was still in force, which showed reduction complete. A transverse incision was next made over the symphysis pubis and both pubic bones drilled; a wire was then passed through and tightened while the bones were being approximated by external pressure. A broad band of adhesive plaster was then passed snugly about the pelvis and a plaster-of-Paris cast applied,

including both thighs to the knees and extending upward as high as the axillæ. Later examination by X-ray showed that some upward and lateral displacement still persisted. This was overcome by cutting a window in the front of the cast, over the pelvis, and inserting through it, between the pelvis and the cast, a heavy piece of sadler's felt on each side. A strong muslin bandage was then passed around outside the cast and loosely knotted. Through a loop in this the end of a rod two feet long was passed and tightened by twisting after the manner of a Spanish windlass. When sufficiently snug the rod was held in place by adhesive plaster. Next a weight of 22 pounds was fastened to the leg and passed over a pulley at the foot of the bed. With this X-ray showed the deformity corrected. The cast and weight were removed September 23d, and the patient left the hospital October 1st.

He returned to work June 4, 1917, after a period of disability of ten months and eight days. Recovery was in every way complete, with no shortening of the limb nor loss of function.

**REMARKS.**—Much confusion regarding this injury prevails in the profession. Says Eisendrath<sup>1</sup>: "A diastasis or dislocation at one of the symphyses is extremely rare, and it is impossible to recognize it during life." According to Stimson<sup>2</sup>: "Pure separations at these points (the symphyses) without fracture are rare, and except at the symphysis pubis, hardly to be diagnosticated during life." Malgaigne gave a classification of luxations of the pelvic joints, but failed to differentiate simple luxations from luxations complicated with fracture, and his classification has generally been discarded.

Hitherto a comprehensive search of the literature of this lesion seems not to have been made; consequently we may be pardoned for having attempted one. The search has resulted in the discovery of only eleven fairly well authenticated cases. Cases of subluxation and luxation complicated with fractures of the pelvic bones and so-called sacro-iliac relaxation, sacro-iliac slip, etc., also pathological luxations and the condition arising in the pregnant state have been excluded.

The luxation, in the frequently quoted case of PHILIP,<sup>3</sup> reported in 1763, was probably pathological, since the diagnosis was not made during life and at autopsy a large amount of pus was found in the sacro-iliac joint.

According to SALLERON, the first case of sacro-iliac luxation to be observed and placed upon record was that of ENAUX<sup>4</sup> which occurred in 1784. In this case the left innominate bone was luxated upward and backward. The diagnosis was confirmed by Hoin and Chaussier. Attempts at reduction in this case failed, but it is stated that after being put on crutches the weight of the limb effected reduction.

In the case of THOMASIN,<sup>5</sup> 1785, no doubt sacro-iliac dislocation was present, but sufficient care was not exercised in observing and reporting the case to exclude the presence of fracture as well.

In the case of BAKER<sup>6</sup> reported in 1830 autopsy showed sacro-iliac luxation, but there was also present a small fracture of the ilium.

The case of TRACHEZ<sup>7</sup>: A military officer, 38 years of age, of good constitution, and above medium height, fell from the third story to the street pavement, March 15, 1837. He alighted upon the two ischial tuberosities, in such a way that the two

innominate bones were carried upward and the sacrum forced downward. Great pain and tenderness about both sacro-iliac symphyses followed. The iliac crests were elevated on a level with the false ribs, and there was present paralysis of both lower limbs, bladder and rectum. No attempt was made to reduce the luxations and they became permanent. The paralysis improved only partially, so that when seen nearly ten years later his recovery was very imperfect. His height was reduced in proportion to the relative elevation of the innominate bones.

The case of THUVENET,<sup>6</sup> 1849: A man of 27 years of age, of athletic build, while working at a quarry, a cave-in of earth fell upon his back, throwing him violently to the ground upon his abdomen.

Two hours later he entered the hospital in a very grave condition. Swelling and ecchymosis covered the anterior inferior abdominal wall, inguinal regions, scrotum and perineum. Catheter inserted into the bladder drew off only a small amount of blood. He died 44 hours after entering the hospital, before any diagnosis of injury to the skeleton had been made. Autopsy revealed extensive infiltration of the pelvis, abdominal wall and subperitoneal tissue with blood. There was an irregular laceration of the anterior wall of the bladder three centimetres long. The symphysis pubis was disrupted and the bones separated the distance of two fingers' breadth. The left sacro-iliac symphysis was completely destroyed; that of the right almost so. The sacrum was easily detached.

The case of PARMENTIER,<sup>7</sup> 1850: A heavy oaken door fell upon a man passing, threw him to the ground upon his back, crushing the entire body, the head only escaping. Separation of the symphysis pubis was immediately recognized on his admission to the hospital. The right was elevated above the left; the abdominal wall and perineum were contused and infiltrated with blood. Patient died 24 hours after the accident. At autopsy blood was found in the peritoneal cavity. The right pubis was found elevated three centimetres above the left. All of the ligaments of the right sacro-iliac symphysis were torn through. The ilio-lumbar and the sacro-sciatic ligaments were likewise torn through. On the left side the sacro-sciatic ligament and the anterior sacro-iliac ligament were torn, but the interosseous ligaments, ilio-lumbar and the posterior sacro-sciatics were sound.

Case of FLEMING,<sup>8</sup> 1855: While a stout youth, aged 19, was in the act of leaping from a cart in motion, his feet became entangled in a rope, and he fell to the ground, alighting on his face, and while in this position the wheel of the cart passed obliquely across his pelvis. The cart and its load weighed nearly two tons. On admission to the infirmary, a few hours after the accident, the left ilium was found to project about an inch further behind the sacrum, and its crest was fully an inch and a half higher than on the right side. Hip was elongated and swollen, but depression at the joint and projection at trochanter were quite distinct. Motions of hip, knee, and ankle joints were free and unattended with any marked pain. Limb was shortened by fully an inch. He complained of pain at lower part of abdomen, and was unable to void urine, requiring the use of the catheter.

When dismissed the limb was shortened about three-quarters of an inch, the left ilium appeared as much higher than its fellow, and projected slightly more behind the sacrum.

In 1871 SALLERON<sup>9</sup> published a notable memoir upon traumatic luxations of the pelvis, in which he reported three cases which came under his own observation, and reviewed the literature in some others. His cases occurred in connection with his service with the French army in northern Africa.

OBSERVATION I.—B. C., aged 26, native of Sardinia, master mason, healthy man of good constitution, but of slender build, August 29, 1849, fell to the bottom of a well 12 metres in depth, the fall being unbroken by any obstacle. He alighted upon the buttocks, all of the weight of his body being transmitted to his left buttock, which struck upon a slight ridge. He retained consciousness and soon experienced

## LUXATION OF THE SACRO-ILIAC SYMPHYSIS

a desire to urinate without being able to accomplish the act. When he arrived at the hospital, diagnosis of forward and upward luxation of the second part of the sternum upon the first was readily made, also luxation upward and backward of the left ilium upon the sacrum. The left anterior superior spine was strongly depressed and sunken into the abdominal wall. The anterior superior spine and crest of the left ilium were elevated 15 to 18 millimetres above corresponding parts of the right. The left posterior superior spine made a very noticeable prominence. The left leg was extended parallel with its fellow, toes slightly everted. Measurement from the anterior superior spine to the tip of the malleolus showed no shortening, though the left knee was on a higher plane than the right.

The manner of reduction was interesting, but the description is too long for insertion here. He was discharged 47 days after the accident.

OBSERVATION II.—A. D., age 36, Zouave of medium height and good constitution, while intoxicated fell from the second story window of his barracks and struck the posterior part of the right side of the pelvis upon very hard and uneven ground. Examination showed marked prominence of the entire right iliac region. The right anterior superior spine of the ilium was elevated 10 to 12 millimetres above the left and on a plane anterior to it. The iliac crest obviously approached the false ribs. The right pubic spine formed a marked prominence, was elevated above and on a plane anterior to the left; movement of the right hip-joint was free and painless. Spontaneous reduction occurred on turning the patient on his left side and he left the hospital 46 days after his injury and recovery was complete at the end of three months.

OBSERVATION III.—M. J., Spaniard, age 38, excavator, was thrown down upon the anterior surface of the body by a slide of lime stones, which fell from a height of four or five metres, and covered him almost completely. He experienced severe pain in the pelvis, and diagnosis of forward luxation of the ilium upon the sacrum was made upon the following indications: The left hip formed a very marked prominence forward and outward; the anterior superior iliac spine projected forward and upon a plane anterior to the right; the left iliac crest was more elevated than the right; the left posterior superior spine was completely effaced and marked tenderness to pressure over its site was noted. Tenderness was very marked at the site of exit of the sciatic nerve from the pelvis and at the symphysis pubis. Spontaneous reduction occurred on the fifth day. The injury was followed by atrophy of the left lower limb, supposed to be due to nerve injury at time of accident. He was discharged 86 days after injury.

Case of J. THORNSBY JONES: H. J., age 55, powerfully built, was admitted to St. Bartholomew's Hospital, January 17, 1878, having been knocked down by a traction engine an hour before admission. The urine was passed voluntarily and was free from blood. He died seven hours after admission.

*Necropsy.*—The intestines and all of the organs, both abdominal and thoracic, were in a healthy condition and none were injured. After removing the small intestines, an extravasation of blood was found occupying the rectovesical pouch and the loose tissues around; and on dissecting through this, the ilio-lumbar artery on the right side was seen to be wounded. The veins on this side were unhurt; but on the left side, the external iliac vein was wounded at a point opposite the sacro-iliac articulation. On removing the rectum, bladder, the vessels, and the loose tissue from the pelvis, it was at once seen that the sacrum was unusually prominent; and further examination showed that it was separated from its articulation with the ilium on each side. The anterior sacro-iliac ligament was ruptured, all but a few fibres. The anterior border of the articulating surface of the sacrum was at least a quarter of an inch in front of that of the ilium on both sides. The posterior aspect of the articulation was then examined, and here the ligaments could not be well defined on account of laceration of the gluteus maximus and the extravasated blood. A careful

examination was then made of the whole pelvis and at no point was a fracture found.

Case of WILHELM,<sup>10</sup> 1899: Man aged 46, upon whom an elevator, which with its load weighed 2000 kilograms, descended, pressing downward upon his back. It held him in that position for 20 minutes. He entered the hospital in profound coma; pulse 140 and thready. The catheter drew off urine at first clear, later faintly sanguineous. The two iliac crests formed two enormous posterior prominences; the posterior part of the left iliac crest in particular nearly touched the lower border of the ribs. He left the hospital two months later, walking with two canes; his attitude was inclined to the left with notable forward flexion of the body. The ilio-sacral troughs were very deep, particularly the left. In walking the patient executed a movement of balancing the trunk similar to that of a patient with double congenital dislocation of the hips. He had lost 6 centimetres in height and there remained certain nervous disturbances in the lower extremities. The forward luxation of the sacrum, without separation of the pubes, remained.

Case of HOPKINS,<sup>11</sup> H. F., aged 18 years, was admitted to the Pennsylvania Hospital December 23, 1898, having been caught in an elevator. On admission he gave evidence of considerable shock. The left limb was shortened and the foot everted. Examination of the hip showed it to be unhurt. The left ilium was found to overlap the sacrum, so much so that the tips of the fingers could be insinuated beneath it, as they can beneath a scapula. Exploration was made for the other point, which had yielded to allow of this break in the pelvic ring, and it was found at the symphysis pubis. The joint was quite mobile, this being easily discernible by pressure upon the anterior processes of the ilium. A deep right-angled contusion of the integument over the left side of the sacrum testified to the violence of the forward pressure. There was no paralysis, nor was there evidence of concealed hemorrhage of any severity. Reduction in this case was not quite complete; however, it is stated that patient made a good recovery.

In closing, the author states: "While not attempting, therefore, to have exhausted the literature of this very rare and interesting injury, I venture the opinion that it is the first case recorded of complete sacro-iliac dislocation occurring in a sound pelvis to recover after reduction." This opinion is controverted by the cases that have been collected in this paper.

The case of BRAQUEHAYE,<sup>12</sup> Adda, and Bruch, 1913: Cameille W., female, age 21 months, born at term and in good health. The nature of the traumatism in this case was not determined. She was supposed to have fallen from the top of a table or from a nurse's arms. A correct diagnosis was not made until 31 days after the injury, when radiography showed wide separation of the right sacro-iliac symphysis. Five days later the luxation was reduced, with the patient under chloroform. The operation was guided by the fluoroscope. The right lower limb was placed in a plaster-of-Paris cast, in extension and forcible abduction. This was maintained for more than three months, and eight months later patient was perfectly cured, walking without a limp. DELBEAU<sup>13</sup> reported a case of luxation of all the joints of the pelvis, which, however, was complicated with a very small fracture of the right ilium.

Diagnosis with the aid of X-ray is easy, without it difficult and uncertain. Certain changes in anatomical form are observed in the region of one or both innominate bones. There is shortening of the limb on the affected side when measured from the umbilicus, and no shortening when measured from the anterior superior spine. When the innominate bone is released from its attachment to the sacrum and to its fellow at the symphysis pubis, the powerful muscles attached to it from above draw it upward. There is generally external rotation of the limb with the toes in eversion, due to change in relative position of the cotyloid cavity. Some

authors emphasize the importance of digital exploration by the rectum. It is needless to say that all serious injuries about the pelvis should be subjected to X-ray examination.

The prognosis is grave; the injury is nearly always followed by severe shock. In the 12 cases reviewed above, including my own, there were three deaths, a mortality of 25 per cent. Death is not due to injury to the skeleton, but the great violence necessary to produce this lesion expends itself upon the blood-vessels and viscera; of the viscera the bladder is the one most often wounded. In nearly all cases inability to void urine was recorded. In one case both limbs were partially paralyzed which condition became permanent. In another the leg on the affected side atrophied. In one case the stature was shortened by 6 centimetres. In one other there was shortening of stature, amount not noted. In five of the cases disjunction at the symphysis pubis was noted. In two cases the result was recorded as perfect. In both the diagnosis and treatment were conducted under the guidance of radiography. Three of the cases were due to elevator accidents.

When the luxation is complicated with fracture of the pelvic bones, Salleron believed that the luxation occurs first and the fracture results from the continued action of the luxating force.

The treatment has already been sufficiently described.

From the facts which we have presented it is clearly evident that simple luxation, caused by external violence, of the sacro-iliac symphysis with or without separation at the symphysis pubis, though very rare, is entitled to a place among well recognized traumatic lesions.

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## FIBROCYSTIC AND CYSTIC LESIONS IN BONE

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THE fibrocystic and cystic degenerations found in the benign and malignant neoplasms are not included in this paper. Only those lesions in bone that conform to our modern conception of inflammation and its allied processes are here considered. We must, of course, bear in mind that these fibrocystic changes are always secondary and chronic.

A careful study and survey of the literature covering the subject of fibrocystic and cystic lesions in bone reveals very clearly that there exists a great diversity of opinion among men interested in bone surgery in their expressed views regarding the etiology of these diseases. One also gathers from a perusal of the literature that the methods of reaching correct diagnoses are sometimes far from exact. The most common sources of error seem to be caused in mistaking a generalized or systemic pathologic process for a purely localized condition. Another source of error is in calling a lesion "bone cyst," from the appearance of the radiographic picture, alone. It must be borne in mind that a localized spot or area of osteolysis, that the X-ray plate reveals, is not necessarily a bone cyst. Elmslie's elaborate paper covers the consensus of opinion held up to 1914.

Accumulated experience gained in the surgery of pathologic bone processes confirms the writer in the belief that a simple regrouping of these lesions is desirable at this time, particularly in view of the fact (thanks to the illuminating data obtained by the Röntgen ray) we now know they are not uncommon. A simple division of the non-neoplastic lesions into two separate groups has distinct advantage because it enables us, in a clear, concise and comprehensive manner, to include practically all the pathologic processes coming under these headings. Group 1 should include all multiple fibrocystic and cystic lesions, *i.e.*, multiple lesions in a single bone, single lesions in numerous bones and multiple lesions in several bones. All diseased processes covered by this group may be considered as being due to some general systemic disturbance. Group 2 includes all the solitary fibrocystic lesions that conform to our modern conception of a non-neoplastic state. These single bone pathologic processes cover, by far, the greatest number of the affections in bone that are fibrocystic in character. They embrace the most important group from the standpoint of the surgeon. The large majority of them are amenable to surgical intervention and cure. Some of the solitary lesions that present in a single bone are undoubtedly due to pathologic change, general in character. These and their diagnoses will be discussed with the solitary lesions.

*Etiology.*—The main etiologic factors causing the multiple lesions in



Group 1 are: (a) metabolic, (b) syphilis, (c) tuberculosis, (d) other bacterial infections, (e) parasites, (f) hæmophilia.

In the second group, localized trauma is the apparent factor in 75 per cent. of cases, the remainder of the solitary lesions come under the factors cited in the first group.

GROUP 1.—(a) *Metabolic Processes*.—Faulty bone metabolism is quite generally believed to be due to an interference with endocrinal glandular equilibrium. Recent investigations seem to show that the parathyroids play a rôle in calcium content control. Experimental work done by McCrudden has been most interesting in showing that improper nutritive balance is a factor in faulty bone metabolism. He found that feeding with foods lacking in calcium salts never decreased the calcium output, and that, after a period of such dietary, bone softening occurred. We must regard this process of softening as one of the steps aiding in the later formation of general multiple fibrocystic and cystic lesions in bone. Von Recklinghausen's work (published in 1910, under the title "Rickets and Osteomalacia") covers the subject of these general systemic metabolic bone changes in all their phases. He has grouped them under the term "malacia," *i.e.*, myeloplasmic, phlegmatoplasmic, metaplastic, etc. Metaplastic malacia is, perhaps, of most interest to the surgeon because it embraces, first, the fibro and fibrocystic type of lesion commonly termed "osteitis fibrosa," and, second, the hyperplastic form usually described as "osteitis deformans or Paget's disease." The fibrocystic stage of the lesion is always deficient in lime salts. The hyperplastic solid phase (osteitis deformans) has been shown by DaCosta and others to exhibit areas of lime salt content in greater amount than normal, as well as an increase of the so-called osteoid tissue. In the writer's opinion, both so-called osteitis fibrosa and osteitis deformans have their genesis in the main, in an excessive hyperplasia of soft fibrous structure, whose origin is the reticulum of the bone marrow. During the formation of this soft fibrous hyperplastic tissue, there apparently is produced a partial or complete obliteration of many of the small vessels, thereby causing inhibition of bone nutrition with resultant halisteresis or absorption. This tissue, at the stage of cystic formation, seems to have no affinity for lime salts. Whereas, the solid lesion or lesions we term "Paget's disease of bone" exhibits not only dense fibrillation but also, according to recent investigation, presents an increased lime salt content. This stage of the metaplastic process is believed by some observers to be a reconstructive effort.

Hirschberg, who described the fibrocystic lesion in 1889 as osteomalacia with cyst formation, came nearer the mark than von Recklinghausen, who, in 1891, gave it the title "osteitis fibrosa." One gathers from the latter's work (published in 1910) his recognition of the accuracy of Hirschberg's definition, because in that publication he classifies the lesion under the heading "metaplastic malacia." Berard and Alamartine (in their paper published August to November, 1915) do not feel the term "osteitis fibrosa" properly describes these osteodystrophic fibrocystic processes in bone. They consider the lesion or lesions a diffuse process and give their pathologic findings:

"The gross pathologic picture sometimes shows areas of brown or reddish-like masses composed of bony and medullary tissue, which, under the microscope, looks like myeloplax sarcoma. Cystic areas are sometimes seen containing only serous or sanguinous fluid. The soft fibrous structure is slightly vascular; this tissue, poorly nourished, gradually increases in softness and little by little gives birth to multiple cysts." They also express the view that these osteodystrophic lesions are not uncommon in old people. The writer is able to confirm this observation.

The observations of Berard and Alamartine regarding a mixed pathologic picture is in full accord with the earlier views expressed by Hirschberg, Rehn, von Recklinghausen, Bloodgood and others. None of the observers have explained or apparently considered the giant-cell content, with the exception of Bloodgood, who states:

"Although giant-cell tumors are found in many bones, in not a single instance has metastasis to internal organs been found."

It does not seem to have occurred to these observers that the so-called giant-cell sarcoma areas within these generalized fibrocystic processes were, in fact, an exhibition of an active localized and local regenerative effort and that the presence of the granulation tissue mass was the best possible evidence of an attempt at repair and restoration. The same may be stated of the giant-cells found in these lesions; their presence has always been noted in structure containing inert absorbable sterile substances. It has never been demonstrated that the giant-cells, accompanying granulation tissue proliferation in structural defects, had other function than that of scavenger, or that such cells have anything whatever to do with neoplastic growth. The microscopic picture of fibrosis found in these lesions simulates, in a marked degree, the fibrosis of a chronic cystic mastitis.

(b) *Syphilis*.—The inherited or congenital form of syphilis not infrequently exhibits localized areas of disease in the cancelli, particularly of the long bones, that are fibrocystic or cystic in character. The lesions may be limited to a single or occupy several bones. They are less frequently seen in acquired syphilis. They are primarily due to infiltration of gummatous foci, which has produced bone destruction. The products of the gummatous mass have become absorbed and the fibrocystic or cystic lesion is left as an end-result. The bones presenting these lesions may not give any of the usual pictures suggestive of syphilis, such as general thickening of the cortex, periosteal inflammation, bowing, or irregularity of the peripheral lines. Indeed, where only a solitary lesion exists in the cancelli, one must often remain in doubt as to its true etiology, even with all the criteria of syphilis present.

(c) *Tuberculosis*.—Rarely causes multiple fibrocystic or cystic lesions in bone.

(d) *Other Bacterial Infections*.—In their chronic phases sometimes present localized areas of osteolysis near joints that are found at operation to be fibrocystic or purely cystic in character.

(e) *Parasitic Cysts*.—The writer has observed only one case in a series

of thousands of bone lesions. The infecting parasite proved to be an echinococcus found in the upper end of the femur.

(f) *Hæmophilia*.—A lesion, presenting under the X-ray a localized area of osteolysis in the upper end of the tibia, has been observed in a very much enlarged hæmophilic knee.

GROUP 2.—Includes the solitary fibrocystic and cystic lesions in bone that arise independent of degenerative cystic changes in benign or malignant neoplasms. These solitary pathologic processes in bone cover, by far, the greatest number of the affections that are fibrocystic or purely cystic in character. It should be emphasized that the lesions are never primary; always chronic and usually inactive. The apparent etiologic factor in about 75 per cent. of the solitary processes is bone trauma, due to direct injury, dating back months or years. In every instance of immediate injury, or destruction of portions of the cancelli in normal bone, the later fibrocystic changes are preceded by primary effort at repair in the formation of granulation tissue. The metaplasia or conversion of the granulations into fibrous structure really exhibits failure of the effort at complete anatomical and physiological restoration. It represents partial cure and is an end-result. The same efforts at reconstruction take place in localized lesions that are brought about by the hæmatogenous bacterial infections, by syphilis and by tuberculosis.

Solitary lesions frankly cystic are not uncommon; they may be caused by any of the above-mentioned etiologic factors. They are usually entirely free of detritus, granulations, or fibrous structure, containing, at times, clear straw or sanguineous fluid. The cavity is cemented by a wall of osteofibrosis, or by a dense, bony shell ranging from 1 to 5 mm. in thickness. When a lining membrane intervenes, the bony or osteofibrous wall is usually absent.

The cysts found in so-called medullary giant-cell sarcoma (hemorrhagic osteomyelitis) should be grouped with the fibrocystic inflammatory lesions of bone. We cannot agree with those who regard these cystic processes as degenerative, any more than we can regard the granulation tissue content in such lesions as neoplastic. The fibrous metaplasia of the granulation tissue produces contraction and retraction of structure, leaving cystic areas. The same process of repair that falls short of complete restoration may be observed in many inflammatory bone lesions. The disease should be regarded as local. The rôle the giant-cells play in this inflammatory bone affection has been published in detail (see ANNALS OF SURGERY, February, 1917).

Single fibrocystic lesions, due to the general systemic disease "metaplastic malacia" of von Recklinghausen, or "osteodystrophy" of Mikulicz, give an entirely separate picture compared with those local lesions due to trauma or to the isolated pathologic processes caused by infection. The former, in so far as our present knowledge obtains, is metabolic.

The disease is well described by Berard and Alamartine as: "A diffuse, fibrous or fibrocystic process, composed of tissue poorly nourished and soft; increased softening gives rise to multiple cysts."

The condition is a progressive one. On the other hand, the pathologic picture we obtain of the tissues in localized lesions, due to trauma, are very different. In the traumatic lesions, the fibrous structure is quite firm, dense and avascular when fully organized. Here the lesion represents the terminal stage of a primary process that had its beginning or origin in a localized hemorrhagic osteomyelitis, which, in its turn, had been preceded by direct mechanical injury, or by the spirochætæ, the tubercle bacillus, or some other infecting organism. In these cases, further bone or tissue destruction, or increase in size of the lesion, does not occur.

*Clinical Picture.*—The clinical picture obtained from the history and examination in the solitary secondary processes is never striking and is sometimes negative. The lesions are more frequently observed in the first two decades of life. In a majority of instances a careful questioning will elicit from the patient the recollection that months or years before a blow, fall, injury, or contusion had occurred at the site occupied by the lesion. Constant pain is never present; sometimes there is noticeable localized enlargement surrounding the lesion. If the disease is near a joint, there is usually some limitation of motion; tenderness upon pressure is always present. In the lower extremity, a slight limp is rather a constant accompaniment. In some instances, it is quite true that the first intimation of the presence of a fibrocystic or cystic lesion in bone is brought to our attention by a pathologic fracture. We are not justified, however, in assuming from a röntgenogram, that shows an area of osteolysis at the site of the fracture, that the lesion is either solid, fibrocystic or a bone cyst. Single lesions giving no history of bone trauma may be regarded as being due to one of the acute infective organisms, to syphilis, tuberculosis, or to one of the malacias, *i.e.*, myeloplastic or metaplastic.

Multiple lesions, when due to the malacias, in so far as one may gather from the literature and from observation of cases of my own, are not ordinarily productive of pain; the individuals come for treatment of some deformity or fracture. One patient, who has been under observation for six years, shows X-ray fibrocystic lesions in his pelvis, femoræ, tibiæ and fibulæ (all bones above the pelvis are normal). He has never had any illness, never any pain, numerous blood pictures have been normal, urinary examinations always negative, no Bence-Jones' bodies. He looks physically well. First came for treatment of deformity following fracture of femur. In all cases where we suspect pathologic fracture, our routine practice is to have the entire skeleton röntgenographed; the value of such a procedure was graphically shown in this case.

*Diagnosis.*—A careful interpretation of the clinical facts taken in conjunction with the gross pathology the röntgenogram reveals in these lesions enables one to make a presumptive diagnosis. No pre-operative method or study compares in value or importance to the information given by the X-ray in permitting a decision regarding the presence or absence of an area or areas of osteolysis. Its value is negative, however, in deciding whether the lesion is a solid focus of organizing or organized soft tissue, pus, or fluid, or

of indicating the presence or absence of a lining membrane, or membranous septa.

The statements frequently made that a localized bone abscess, without bony sequestra, may always be diagnosed from the röntgenographic picture does not hold good; the dense, bony wall or ring sometimes shown immediately surrounding a bone focus may enclose solid soft tissue or fluid without evidence of pus; on the other hand, lesions presenting no dense, surrounding bony wall may contain pus, fluid or soft tissues. It is, in fact, practically impossible to differentiate the type of solitary lesion from any set of röntgenograms taken during any one seance, *i.e.*, between a localized hemorrhagic osteomyelitis, a simple cyst, a sterile abscess without sequestrum or a fibrocystic process. If a series of pictures are taken at intervals extending over a period of time, a more exact X-ray diagnosis is probable.

The writer has been able to make the differential diagnoses from röntgenographic studies, where the opportunity has presented, and for the time being operation has been refused, and offers the method as a new diagnostic measure. For this purpose it is essential to take numerous X-rays extending over weeks and perhaps months. In the first place we know that the localized lesion hemorrhagic osteomyelitis and the solitary fibrocystic lesion due to metaplastic osteomalacia, both slowly increase in size and to this extent both lesions are alike. The differential diagnosis between these two processes is that in the X-ray the former gives a more clearly defined picture, greater regularity of outline and is more nearly circular or oval in shape, dependent upon its location in cancellous structure. The fibrous or fibrocystic metaplastic lesion is less clear cut, its edges have more the appearance of fading away where it is not controlled by periosteum; it is never circular and rarely clearly oval in shape.

In the second place the fibrocystic and cystic lesions, whose origin is not metaplastic, nor due to parasites, do not increase in size. They are an end-result of the process of repair. Chronic sterile bone abscesses, without sequestra, also remain stationary; a differential diagnosis with the X-ray is difficult or impossible. As all these lesions are surgical, confirmatory diagnosis may be obtained at operation.

A diagnosis of the multiple fibrocystic lesions in bone is best made by correlating the clinical with the X-ray findings. They are generalized processes and may be regarded as being due to disturbances producing the malacias, or to syphilis. Multiple fibrocystic processes due to other infections are rare.

*Treatment.*—Treatment of the solitary lesion resolves itself into the method of surgical procedure.

As bone is perhaps the most sensitive structure in its response to infection, very careful operative technic is essential. The operation is usually simple and minor. Following thorough curetting, the cavity should be swabbed with tincture of iodine, especially for its irritant stimulating regenerative effect. The writer advises against the use of carbolic acid, zinc, or other destroying chemicals followed by the use of alcohol, now com-

monly used for swabbing cavities following curettement in bone. The destructive effect of the acid or zinc is certainly not conducive to granulation tissue proliferation, nor can it aid in the final production of bone to obliterate the cavity. Silver's very instructive case, which at secondary operation showed a dense membrane lining the cavity of a lesion removed a year before, was partially, if not wholly, brought about in the writer's opinion by cementing the walls at the primary operation with carbolic acid and alcohol and perhaps aided to some extent by the plug of tissue left in the cavity. Thorough curetting, removing all obstacles to the outcropping of normal granulations, is the first essential for the final formation of bone and obliteration of the cavity.

Tincture of iodine is not used for its destructive effect—it seems to have none—but for stimulating the formation of healthy granulations. All cavities larger than a pigeon's egg are aided in shortening the process of repair and cure by filling with bone shavings which may readily be taken from portions of the bone above or below the lesion. Whether or not osteogenesis takes place in the shavings, they at least act as a scaffold in supporting the blood clot filling the cavity, the blood clot, in turn, acts as a prop or framework in supporting the out-cropping granulation tissue buds and fibrils which in its last phase will become bone.

The use of the "plombierung" of Moosetig-Moorhof has the following disadvantages over the above simple method of filling bone cavities: *First*, the cavity must be absolutely dry. *Second*, the preparation must be in exact proportion as to ingredients. *Third*, it must be poured into the cavity at a certain temperature difficult to maintain, otherwise the mass shrinks at its periphery and is not in absolute contact with bone, a condition, according to Moosetig-Moorhof, fatal to success, and finally the iodoform content of the plug is in some cases intoxicant to the patient.

The objection to Beck's bismuth paste is that it does not always absorb. The same objection holds for the "agar-agar" jelly of Mikulicz.

Very large lesions that exhibit excessive vascularity, following a thorough curetting, may be tightly packed for a few days before closing, otherwise all wounds should be immediately closed without drainage.

The clinical pictures and röntgenograms of a few illustrated cases selected from the wealth of material at our disposal in the New York Hospital for Ruptured and Crippled, are appended:

CASE I.—*Metaplastic osteomalacia-mixed hyperplastic and fibro-cystic types.*

Raymond C., male, white, unmarried, aged thirty-two years. Mother died during his infancy. No brothers or sisters. Can tell nothing about father. Has no knowledge of any diseases of childhood excepting that he was sickly. In 1896, when he was ten years old, was taken to the Presbyterian Hospital for trouble with left hip, said to be tuberculosis. Remembers the leg was put up in extension; he left the hospital several weeks later wearing a brace and high shoe. Thinks he wore the brace and shoe for several months. In 1900 had

attack of severe pain in the left leg and hip. Was sent to St. Mark's Hospital, where he remained for one month. During his stay in St. Mark's the peculiar shape of his legs and the lumps in buttocks and thigh were first noticed. Remained well until 1905, when he ran a nail in his right foot. Three days following this accident infection of the foot and leg set in and lasted for four weeks. This was followed by contractures of knee and foot. He entered Bellevue Hospital later in the year for treatment of the contractures. He states that he was put up for five or six weeks in extension, with good results, when he left the hospital, but was compelled to return again in two weeks time, because severe pain in knees and hips had returned. This time he remained for five months, when he was discharged, "cured." In December of 1905 he entered Bellevue for treatment of d. w. f. On this occasion the masses were noticed in his thigh and specimen removed for diagnosis. The report returned from the Loomis Laboratory was "sarcoma." Was advised to have the masses removed for the purpose of making a toxin, which he refused. He states that these lumps in the buttocks and thigh have never given any pain and that he does not think they have increased in size. In January, 1906, he was referred to Doctor Coley, who removed a section from the mass in the right thigh, which, upon examination, was reported "sarcomatous." He then underwent treatment with Doctor Coley with toxins for ten weeks, at the end of which time he refused further injections. Six months later an ulcer broke out just above the inner side of the left ankle. Mercurials and iodides were used extensively for about ten months without much apparent improvement or relief. During convalescence and recovery from German measles the ulcer healed. A year later another ulcer appeared, 1 inch above the old one. This one took about one and one-half years to heal. In 1911 went to the Presbyterian Hospital. During his stay in the Presbyterian Hospital he was given several doses of salvarsan. Another piece of tissue was removed from the mass in his thigh and pathological report returned states that the mass was mostly cartilage. Later in 1911 the hamstrings at the right knee were cut for marked contractures. Since the operation the knee has been ankylosed. Had Neisserian infection five years ago. Has had 8 Wassermanns taken, all of which have been negative; a Wassermann was taken two or three weeks ago by Dr. Cyrus Field with a highly sensitized antigen, who states that it reacts "slowly negatively." In 1916 he underwent a course of mixed treatment in Bellevue; several months later was advised that mixed treatment was of no benefit. In April, 1917, another ulcer broke out near the site of the first two, which is still active.

*Examination.*—Patient under-nourished. Shows large irregular, oval-shaped ulcer about  $2\frac{1}{2}$  inches long by  $1\frac{1}{4}$  inches wide. It is neither specific, trophic nor decubitus in type. He has marked limitation of motion in all joints of the lower extremities, with both knees in slight flexion and adduction. The X-ray pictures, from the pelvis down, show marked disturbance of the bony structures and apparently two different type lesions are present. From the pelvis up, bones give a mixed gross pathologic picture and are all normal. The two chondro-

osteomatous masses are freely movable in each buttock, and may be regarded as of congenital origin, having nothing in common with the generalized bone lesions.

CASE II.—*Metaplastic osteomalacia, fibrocystic.*

Maurice C., aged sixteen years, reported in detail in *ANNALS OF SURGERY*, February, 1915. General condition to-day practically the same as in previous report. All blood and urinary tests are negative, all bones above the pelvis are normal. X-ray examination shows slight, if any change, in the pathology of diseased bones. Patient is never conscious of pain or disturbance in lower extremities, does not suffer from weakness or tire easily. Still wears a brace and high shoe on shortened limb. Recent experimental hypodermatic injections of tincture of iodine under the periosteum in the left femur seem to have produced slight localized improvement.

CASE III.—*Localized fibrocystic osteomyelitis, traumatic (secondary to hemorrhagic osteomyelitis).*

Joseph B., male, white, aged twenty-two years. First noticed an oval-shaped lump, size of a small hen's egg, on inner condyle of right femur early in January, 1915. There was little or no pain except on pressure over the lesion; slow increase in size was noted until April in the same year, when it was the size of a large hen's egg. At this time patient fell from a height of 20 feet and fractured the femur along the inner side of the lesion, the fracture extending into the knee-joint. Patient was first seen at the New York Hospital for Ruptured and Crippled in October, 1915, seeking relief for limitation of motion in right knee-joint. He states that the lump on the inner side above the knee has not increased any in size since the accident and that it does not bother him in any way. Another X-ray, taken early in 1916, shows no increase in size of the lesion and no symptoms of activity.

CASE IV.—*Localized area of osteolysis in lower end of left tibia.*

Francis D., male, white, aged thirteen years. Localized pain five weeks. Operation refused. Lost sight of. See röntgenogram Fig. 9.

CASE V.—*Localized fibrocystic osteomyelitis, right olecranon, secondary to hemorrhagic osteomyelitis.*

Pauline D., female, white, aged five and one-half years. Reported in detail (*Surgery, Gynecology and Obstetrics*, July, 1914). See röntgenogram Fig. 10.

CASE VI.—*Localized fibrocystic osteomyelitis, right tibia, upper end, secondary to infectious polyarthritis and multiple osteoarthritis.*

William B., male, white, aged twenty-nine years. Polyarthritis when eighteen years old, several recurrent attacks since. Lumbodorsal spine rigid, limitation of motion in hips, free from pain in spine since pathologic fixation in bowed position. Localized spot near knee-joint very tender on pressure. See röntgenogram Fig. 11.

CASE VII.—*Bone cyst, upper end of femur (left), secondary to hemorrhagic osteomyelitis.*

Francis M., male, white, aged six years. Reported in detail in *ANNALS OF SURGERY*, February, 1915. See röntgenogram Fig. 12.

CASE VIII.—*Localized area of osteolysis, upper end humerus.*

David S., male, white, aged five years. History and symptoms nega-





FIG. 1.—Case I. Metaplastic osteomalacia. Shows destruction in pelvis and femoræ. The two masses below the pubes are separate and distinct neoplastic processes, clinically chondro-osteomata. They are unattached and freely movable in the buttocks, and had remained practically stationary in size for years.



FIG. 2.—Case I. Metaplastic osteomalacia. Showing practical obliteration of knee-joint.



FIG. 3.—Case I. Metaplastic osteomalacia. Note practical absence of cystic areas in tibiae and fibulae. Paget's disease type.

FIG. 4

FIG. 5



FIGS. 4 and 5.—Case I. Metaplastic osteomalacia feet.



FIG. 6.—Case I. Raymond C. Photo shows side view of lower extremity in slight flexion, chondro-osteoma in buttock and protruding trochanter.



FIG. 7.—Case II. Metaplastic osteomalacia. Fibrocystic type, femur and ilium.



FIG. 8.—Case III. Fibrocystic osteomyelitis, secondary to hemorrhagic osteomyelitis. Lower end of femur. Note fracture into joint.



FIG. 9.—Case IV. Localized area of osteolysis. Lower end of tibia.



FIG. 10.—Case V. Fibrocystic osteomyelitis, secondary to hemorrhagic osteomyelitis.



FIG. 11.—Case VI. Localized fibrocystic osteomyelitis, secondary to polyarthritis and multiple osteoarthritis. Lesion is shown in upper end of tibia.



FIG. 12.—Case VII. Localized cystic osteomyelitis, secondary to hemorrhagic osteomyelitis.



FIG. 13.—Case VIII. Area of osteolysis. Middle third of the humerus. Symptom of onset-fracture.



FIG. 14.—Case IX. Lesion in the femur. Patient suffering from congenital syphilis.



tive until brought to hospital suffering with pathologic fracture. Patient was simply splinted with plaster-of-Paris support; no operative anatomic proof of the precise pathology was obtained, therefore a positive diagnosis was impossible. See röntgenogram Fig. 13.

CASE IX.—Localized area of *osteolysis*, middle third right femur, in patient giving a positive Wassermann (Pat. of J. R. Brooke).

M. J., female, white, aged fifteen years. Fracture of thigh eight years ago, occurred while patient was stooping, tripped and fell on leg. For several years practically free from trouble. Pain and discomfort began in thigh ten months ago. Antispecific therapy gave immediate relief and lesion is becoming smaller. See röntgenogram Fig. 14.

CASE X.—Localized area of *osteolysis* in upper end of tibia in a largely distended hæmophilic knee, condition not suspected, revealed on X-ray examination of joint.

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# TRANSACTIONS OF THE NEW YORK SURGICAL SOCIETY

*Stated Meeting, held January 9, 1918*

DR. CHARLES N. DOWD, President *pro tempore*, in the Chair

## MULTIPLE RECURRING FIBROMATA

DR. WINFIELD S. SCHLEY presented an adult woman who, thirteen years ago, had developed on the side of her third toe a tumor the size of a small lemon. A similar tumor had formed in the skin of her back and had been excised some years before. In the scar left by this operation were now small nodules. Before this the heel also had become thickened and had developed a flat tumor formation.

In 1909 the toe tumor was excised. It was not attached to the bone, and was covered with stratified squamous epithelium and epidermis. A few small spindle-shaped nuclei were noted in its stroma. The blood-vessels were very scanty.

Two years after the operation of 1909 the heel began to show considerable growth. On entrance May 17, 1917 (eight years later), there was a large local recurrence involving the third toe. There were some small nodules on the inner side of the foot below the internal malleolus and behind; on her back, nodules in an old scar. There was also a hard small tumor mass on the forearm an inch long by half inch, apparently arising from deep fascia. It was excised first under local anæsthesia and showed simply fibroma.

*Operation* (May 23, 1917).—The third toe was removed by a long V-incision, including the removal of the head of the metatarsal. The large heel tumor was easily removed. Growth arising apparently from the deeper layer of skin or heel fascia. There remained a good fat pad. All the growths which had been excised proved to be pure fibromata without any indication of a fibroma-sarcoma.

## MULTIPLE OPERATIONS FOR GALL-STONES

DR. IRVING S. HAYNES presented a man, aged forty years, who in April, 1916, was subjected to cholecystectomy and appendectomy.

A post-operative ventral hernia followed the cholecystectomy, for the repair of which operation was done at the Park Hospital in December, 1916. Extensive adhesions involved the biliary region and 6 ounces of sterile mineral oil were poured into the region. Suppuration delayed the healing of the wound, but it finally closed, and the patient left the hospital in January.

In April, 1917, the patient was again admitted to the Park Hospital complaining of pain in the upper right quadrant of the abdomen that extended through to the back and right shoulder. This pain had begun in March,



would come on every two or three days. There was no vomiting, no constipation, but the stools were clay colored. The patient was jaundiced and had lost 50 pounds in the last thirty-five days.

On April 25 the third operation was done, consisting of an exposure of the common duct from which a calculus half an inch in diameter and about an inch long was removed. Careful search of the common and hepatic ducts showed no other stones. Recovery was uneventful and the patient left the hospital at the end of the fourth week.

On June 2 he was again admitted to the hospital with a large abscess in the right hypochondrium. This was incised and drained, constituting the fourth operation. He left the hospital with a sinus.

In the following September he was readmitted to the hospital with a persistent biliary fistula. This discharged a very large amount of bile and pus. His blood examination showed a white cell count of 16,500; polymorphonuclears, 82 per cent.; small lymphocytes, 13 per cent., and large lymphocytes, 5 per cent.

At this time he first came under the care of Doctor Haynes. Examination showed nothing except a number of scars in the biliary region and a deep fistulous tract from which bile flowed continuously. The patient's general condition was fair. In order to be prepared against possible contingencies a donor was found for blood-transfusion and her blood tested out and found to harmonize with that of the patient.

On November 1 was attempted the fifth operation. Inasmuch as the usual route to the gall-bladder region had been traversed so often the incision was made parallel with and just below the costal border, directly through the abdominal muscles. This gave ready access to the common duct from the side and beneath the dense adhesions which extended forward to the anterior abdominal wall. The common duct was exposed. It was almost as large as the duodenum. Its walls were an eighth of an inch thick. A large calculus was felt in the duct. The duct was incised for an inch and a half and a calculus, an inch in diameter, easily removed. It was a dark and very soft stone. A second calculus, half an inch in diameter, was found and removed from the ampulla. A large probe was then passed into the duodenum and this followed by an artery clamp, by opening which the sphincter of the duct was divulsed. This was done so as to be sure and secure a free canal into the bowel for the escape of bile.

A careful search, with probes, scoop and finger, of the common and hepatic ducts failed to show any more calculi.

A T-shaped drainage tube had been constructed beforehand. The tubing was one-quarter inch calibre, the short arm about 5 inches long and the long arm about 8 inches. The short part was placed so that it extended from the hepatic duct, through the common duct into the duodenum. The incision into the common duct was partially closed and the region drained by additional wicks of rubber tissue and a small strip of iodoform gauze. The uncontrollable oozing and excessive hemorrhage that was feared did not occur at this time.

The patient progressed well until the fourth day, when blood began to appear through the drainage tube. On the following day almost pure blood escaped, the patient complained of severe pain through the region of the wound and he began to show marked signs of anæmia. These signs of internal bleeding did not diminish even after the use of serum and the region of the operation was distended and painful. Therefore, on November 7, after a preliminary transfusion of 900 c.c. of blood by the syringe method by Dr. Lester Unger, the sixth operation was attempted in a patient nearly moribund.

The entire wound was reopened; foul blood, fluid and clotted with bile and pus to the amount of probably a quart was cleaned out. The T-tube was removed, the wound was repacked loosely with washed iodoform gauze and several drains of folded rubber tissue placed at the lower angle of the wound and the edges brought together by through-and-through sutures of silkworm gut. The subsequent convalescence was very slow, but not stormy. Healing progressed unexpectedly rapidly and at the end of the second week all drainage was out of the wound. Bile appeared in the stools after the third day.

At the end of three weeks the patient was out of bed, his stools were normal and the wound had nearly closed. He left the hospital on December 16, 1917, apparently cured. The reporter called attention to the rapidity with which the soft calculi, removed, had formed; to the very satisfactory exposure and convenience offered by the incision below the costal margin; to the delayed secondary bleeding and to the undoubted benefit obtained by the transfusion of whole blood. He believed that without this precaution the patient would not have survived. Finally, to the solid condition of the scar, although healing took place after suppuration and by granulation, the wound seems perfectly solid.

DR. LUCIUS W. HOTCHKISS stated that he had had a somewhat similar experience a few years ago in a case in which a cholecystostomy was first performed, by another surgeon, with drainage. A sinus had persisted for a long time, then closed, and a resulting infection later necessitated a cholecystectomy and choledochotomy, at which time two large stones were found in the common duct which had not been discovered at the first operation, and their removal was followed by a descent of sandy material from the common duct. The patient apparently made a perfect recovery after long drainage of the common duct, but it was later learned that he was again operated upon about a year later with the removal of another large stone from the common duct. He believed that in such cases, where the common duct is found to contain a quantity of this sandy material, it is probable that a recurrence of stone formation may take place.

#### PULMONARY FISTULA

DR. WILLY MEYER presented a man, aged twenty-four years, who came under his care in November, 1916, with the history that he was taken sick, with pain in the left shoulder region, early in September, 1915. Pain was increased on breathing. After a few days it was present along the entire

left chest; nineteen days later it was necessary for him to take to his bed, as high fever and rapid pulse had set in with choking spells and expectoration of a sputum of brownish color. Early in October a diagnosis of pneumonia was made. Later this was changed to that of advanced tuberculosis, although two tests of the sputum had failed to reveal tubercle bacilli. Patient's pulse stayed high, temperature was in the neighborhood of 104, sputum voluminous, exhibiting a distinctly unpleasant odor. Two months after the onset of the trouble the fever suddenly subsided. Patient was out of bed, with lessened cough, but pulse still rapid; expectoration continued, the bad odor being constantly present, at times also blood. In February, 1916, he left for the country. There, early in March, he suddenly had a coughing attack which lasted almost six hours and was accompanied by the expectoration of blood. Later he had a more severe hemorrhage, and a few weeks later a regular choking spell; during this attack the odor was so terrible that it was impossible for anyone to remain in the room. Early in June, that is, nine months after the onset, a swelling was noticed just below the left clavicle, which gradually grew to the size of an orange. It was diagnosed as abscess of the left lung, incised and drained; no improvement. If he sat up the coughing spells became very severe. He grew weaker and weaker, and the odor from the sputum was very offensive. In November, 1916, he came under Doctor Meyer's care at the German Hospital. At this time, over a year from the onset of his trouble, he weighed but 90 pounds. He had a continuous cough, day and night. From his experience with similar cases Doctor Meyer advised, weak though the patient was, that he assume mornings and evenings a pronounced chest-elbow posture, for thorough expectoration. Following this he experienced the first quiet night he had had for a long time. It was decided to enlarge the fistula and search for the opening into the thorax under regional and local anæsthesia. The operation was technically very difficult on account of continuous coughing spells, and had to be discontinued after the performance of the following steps: The fistula was used as the port of entry; an incision was made, a finger passed beneath the pectoral muscles and these muscles split up to the clavicle; in the second intercostal space there was found a very small granulation and through this was passed a probe into the thorax. It entered a cavity inside, which, in view of the large amount of sputum frequently expectorated, was thought to be due to an empyema. On enlarging this opening as far as possible, the examining finger passed into a very irregular cavity with septa; it was evident that the lung tissue had been invaded. The wound was drained and packed. Soon there was less cough and expectoration. Two weeks later he had such a severe spontaneous hemorrhage from the wound that it was thought he had little chance for recovery. The wound was packed tightly with iodoform gauze and compressed. With intravenous infusion and subcutaneous stimulation he responded; during that night he had a second hemorrhage. On the following morning a transfusion of 800 c.c. of blood from his father was given. The tightly packed wound was left alone for ten days, and on removal of the

gauze there was no recurrence of the hemorrhage. The odor from the sputum had entirely disappeared. Steady improvement now set in; but soon the wound contracted and with it some bleeding and slight odor returned. It was then decided to make permanently a wide opening which could not contract. At this time blood-pressure was below 100 mm. Hg.

On December 23, 1916, again under regional and local anæsthesia, Doctor Meyer reformed the original skin-muscle flaps, resected the third rib and with an incision in the bed of the same exposed the interior of the chest, providing a good view of the lung tissue. Tamponade was done and the flaps allowed to drop in and gradually join with the pleura. Following this there was steady improvement. This summer he was in the country and his improvement continued. He has gained many pounds. When he closes his mouth and compresses the nose he can breathe for hours through this lung fistula.

By increased ventilation of the diseased lung tissue the offensive odor which practically ostracizes these patients, was here again overcome, an observation Doctor Meyer had made repeatedly. He referred to another patient, a young girl, whose case he had reported previously, who had been practically isolated in an institution for months, and in whom drainage of some of the bronchiectatic cavities was followed by disappearance of the terrible odor. In the case now reported it totally disappeared.

The case, it seems, has to be looked upon as one of central subacute (embolic) pneumonia, with subsequent gangrene of the lung. By the operation described the condition was later transformed into a lung fistula. The opening leads into the upper lobe of the left lung. Under illumination large cavities secreting an extremely small amount can be seen.

It is necessary to differentiate between bronchial fistula and lung fistula. The case presented is one of true lung fistula, since the opening leads directly into large cavities within the lung.

The patient is at present in excellent condition, ready to start work in the northern part of the state. Further operating has been advised against for the present.

Should the patient get tired of his condition or uncontrollable recurrence of expectoration or hemorrhages set in—which at present does not seem likely—lobectomy will be indicated.

DR. NATHANIEL W. GREEN said that he had seen a few cases of this kind in which the diagnosis of chronic lung abscess had been based chiefly upon the character of the cough and the odor. There was one exception in a recent case which he hoped later to show before the Society. The patient was an Italian who was coughing up purulent material mixed with bile through a bronchial fistula; possibly the mixture of the bile with the pus was accountable for the lack of odor accompanying the expectoration. Operation disclosed a bronchial fistula leading into a lung abscess which in turn was continuous with an old empyema cavity which in turn had a little opening through the diaphragm about as large as a lead pencil leading into the liver, where there was a cavity about the size of a small orange. This

area was drained with tubes, one set leading into the liver cavity and one set leading into the empyema-lung abscess cavity. The patient gained weight and the discharge greatly diminished.

DR. W. S. SCHLEY stated that he had one case of bronchial fistula in a patient with empyema previously operated upon three times, the drainage wound being allowed to close too soon in each instance. When seen by Doctor Schley he was expectorating bad smelling material and draining from a pin-hole chest sinus over the empyema. He was drained externally and in about four weeks the bronchial opening closed. Then, by the use of aspiration drainage, his cavity was entirely obliterated, although this was considerably over a year from the time of his first operation; he made an excellent recovery. Aspiration drainage Doctor Schley considered very essential in all empyema cases. The above case was recorded and the method of aspiration drainage in an article in 1907.

#### SPLENECTOMY FOR BANTI'S DISEASE

DR. JOHN F. ERDMANN presented a woman, forty years of age, from whom was removed a spleen for Banti's disease, September 28, 1917. Unfortunately, no blood count was taken preceding the operation. There was a large fixed tumor occupying the site of the spleen. The woman had lost a great amount of flesh and was suffering from pain along the upper left quadrant. At operation this mass proved to be a spleen which was densely adherent to all of the surrounding structures. It was removed. It was necessary, owing to the adhesions, to remove a small section of the stomach, a hole about the size of a silver quarter being made. It was also necessary, owing to the dense adhesions, to remove about three-quarters of an inch of the tail of the pancreas. On the thirteenth day after operation she had a dehiscence of her abdominal wound, with some evisceration. The separation was repaired immediately by suturing with three or four through-and-through silkworm stitches.

Her first blood count, immediately after operation, was 4,000,000 reds, 6,000 leucocytes, and 34 lymphocytes. Nine days after the operation her blood count was 4,000,000 reds, 12,500 whites, with 75 per cent. hæmoglobin.

#### OBSTRUCTIVE (MALIGNANT) JAUNDICE

DR. JOHN F. ERDMANN read a paper with the above title, for which see page 274.

DR. FREDERIC KAMMERER stated that he had operated upon two cases of cancer of the ampulla of Vater; in one case, eleven years ago, he had attempted to remove a tumor about the size of a hazel-nut by incising through the duodenum; the tumor was finally removed by resection of the end of the common duct. The latter was reunited with the duodenum by sutures and a cholecystenterostomy was also done. The patient seemed to be doing well, when he suddenly collapsed, on the second day after operation, and died. No autopsy could be obtained. The second case was operated recently; on opening the abdomen the common duct was found to be about the size of an index finger, and by liberation of the duodenum a very easy approximation of the common duct with the duodenum was obtained and a chole-

docho-duodenostomy was performed. The gall-bladder was not drained in this case and everything went well for about five days, when on removing the dressings it was found that at least some of the sutures at the anastomosis had given way and a large amount of bile escaped from the wound. After the lapse of a day or two a duodenal fistula developed, with characteristic discharge from the sinus in large amounts. Rather suddenly the drainage stopped after a further week; the intense jaundice had almost cleared up and continued to disappear until it was entirely gone. There was at no time any further discharge from the wound, which closed rapidly. The patient, unfortunately, died, at the end of six weeks, from a lung abscess. In this case, evidently, some of the sutures at the anastomosis had given way, but the final result was not impaired, as regards the proper functioning of the anastomosis, an observation which others have also made.

DR. WILLY MEYER agreed with Doctor Erdmann that operation was indicated in every instance of obstructive jaundice, and said that he had united the gall-bladder with all the organs mentioned by the author with the exception of the colon; he had only once united it with the stomach. He called attention to the fact that in his opinion the danger lay not with the anastomosis, but with the chronic jaundice which is so apt to predispose to a serious hemorrhage; and he advocates subcutaneous infusions of 3 to 4 ounce amounts of human blood serum on the three successive days before operation or pre-operative transfusion as most efficacious in the prevention of this post-operative parenchymatous hemorrhage. All cases of chronic jaundice should be tested for their coagulation time, and if this is found to be abnormal *pre-operative* precautions as outlined should be taken.

#### HYDRONEPHROSIS

DR. LUCIUS W. HOTCHKISS presented a specimen of hydronephrosis of the kidney, showing well the cause of the hydronephrosis, there being a small calculus shaped like a short horseshoe nail with the point of the nail passing down into the ureter and the head of the nail in the pelvis of the kidney. The patient, who was thirty-four years of age, had suffered from irregular symptoms since childhood. On admission to the hospital there was discovered a movable right kidney and a lumbar incision disclosed an unsuspected hydronephrosis.

#### RECONSTRUCTION OF THE BILE-DUCTS

DR. JOHN F. ERDMANN presented X-rays of the following two cases:

CASE I.—A woman, thirty-four years of age, who was operated, first for cholecystitis, on June 14, 1917, at which time an ectomy was done. The doctor who operated her stated that in trying to stop a hemorrhage from the cystic artery he had evidently included a portion of the hepatic duct. She was jaundiced three days after her operation, never having been jaundiced before or had any pain. Then there was a biliary discharge which started up within a day or two after the jaundice and kept up for about seven weeks. Closure for three weeks. Wound broke open again and

leakage began again and persisted until October 25, 1917, when she was operated in a hospital in New Jersey. Nothing apparently was accomplished and the patient came under observation on November 28. She was badly emaciated, with no jaundice whatever, with an excessive leakage of bile, and two parallel scars in the upper right quadrant, the original scar containing the fistula.

Operation was done on December 3, showing a marked mass of scar tissue in the deep wound. This cicatrix occupied the site of the common duct fully  $\frac{7}{8}$  of an inch long. The sinus led into the duodenum. After tedious dissection the hepatic duct was demonstrated. A catheter was introduced into the hepatic duct, the overlying cicatricial tissue was split so as to bury the catheter in this tissue and allow the distal end of the catheter to be passed into the duodenum, fully six inches in length. Two sutures of chromicized catgut were placed through the catheter, sewing over the surrounding tissues of the duodenum and the contiguous portion of the stomach. Some omental tissue was sewed around the exposed portion of the catheter. Four weeks and six days after operation the patient passed catheter by rectum. There was a leakage of bile from the wound for about three days.

CASE II.—The patient was a woman, thirty-nine years of age. She had been operated some time about the middle portion of 1916. Seen in consultation about six or eight weeks after she had returned home, at which time she was suffering from a deep jaundice. No history of pain—a gradual onset, in other words. No sinus or fistula. She became pregnant in the latter part of 1917 and aborted. At this time she was intensely jaundiced and suffered acutely from pruritus. Seen again on November 30, 1917, at which time she was markedly jaundiced and pigmented and was suffering so that she demanded some operative procedure.

*Operation.*—Upon cutting over the region of her common duct there was found a destruction of the hepatic duct to such a degree that nothing but cicatricial tissue was left. The liver was markedly engorged. (She had, incidentally, lost 27 pounds in weight.) This cicatricial band was the hepaticus in part and the upper portion of the common duct. After much difficulty the upper portion of the hepaticus was demonstrated. Then a filiform probe was pushed down to the common, first rotating the duodenum. A catheter was placed in the hepaticus and then passed through the common and buried in the cicatricial tissue, occupying the position of the lower portion of the communis, then passed fully 6 inches into the duodenum, the tissues around being sewed in after the same fashion as was done in the other operation, reported above. There was absolutely no drainage whatever of bile in this case, except a few days ago, since which time she has been doing nicely.

DR. IRVING S. HAYNES said that in 1913 he had a similar case to those reported, where a surgeon, doing a cholecystectomy, had resected three-quarters of an inch of the common duct. When he later was operating this patient he found the common duct after an arduous search and inserted

a one-quarter-inch drainage tube from the hepatic duct and through the common duct to the duodenum. The patient died from persistent oozing within forty-eight hours in spite of serum treatment. He said that he did not at that time know sufficiently about the preventive treatment of post-operative hemorrhage in severe jaundice by whole blood transfusion, for although he used horse serum in this case it was ineffective.

DR. LUCIUS W. HOTCHKISS said he had had two cases of division of the common duct; the first case occurred in the exploration of the upper abdomen for supposed gall-stones; the patient had no stones, but was suffering from tuberculous peritonitis; in the search for stones the common duct was accidentally divided; an immediate end-to-end anastomosis of the common duct resulted in recovery. The second accident occurred in a case during extirpation of a cyst of the head of the pancreas to the right of the descending duodenum, and in ligating the pedicle, which extended deep into the head of the pancreas, the common duct was opened near its entrance into the duodenum. This was recognized, partly covered in, but a biliary fistula developed. In an attempt to repair this defect two months later the duodenum was mobilized, and a peritoneal and muscular flap was taken from the stomach and pylorus, turned over the opening into the bile-duct and stitched, after tying a ligature around the common duct above the fistula; following this a cholecystenterostomy was performed. There was some slight leakage a few days later, but the patient made a satisfactory recovery and complete closure of fistula was obtained.

DR. NATHANIEL W. GREEN referred to Dr. Arthur G. Sullivan's procedure for repair of the common duct, in which he used on his catheter a bit of rubber sponge, by which when inserted in position the peristalsis of the gut and the tug on the sponge loosened up the catheter, and the same result was obtained as by Doctor Erdmann with his long catheter.

#### DEVICE FOR DRAINAGE IN EMPYEMA

DR. THEODORE DUNHAM presented a drain which consisted simply in the use of the Furniss spool drain, making a valve by attaching a piece of sheet rubber to the external end. This flap does not interfere in any way with the drainage, as it is forced out during expiration; during inspiration the flap drops back into the opening, producing a definite negative pressure in the chest. Its use is particularly advocated in infants and young children.



# TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

*Stated Meeting, held November 5, 1917*

DR. CHARLES H. FRAZIER, President, in the Chair

## PROLAPSE OF THE RECTUM

DR. T. TURNER THOMAS said that in the *Zentralblatt für Chirurgie*, 1909, xxxvi, 1225, P. Sick offered a simple and apparently rational operation for prolapse of the rectum. Since that time Doctor Thomas had operated at the Philadelphia General Hospital on three or four cases by the Sick method besides the cases here reported, and had excised the prolapse in two others. He had not been able to follow any of these cases after they left the hospital. Very satisfactory results were obtained in the two cases in which the prolapse was excised, but the operation was time consuming, rather bloody, and in one it was observed that the rectovesical pouch of peritoneum was included in the excision. One must also consider the possibility of a stricture following this operation.

The Sick operation is much more quickly and easily performed, is more safe and is perhaps as effective. Sick describes it as follows:

A longitudinal incision is made in the raphe between the end of the coccyx and the circular fibres of the sphincter ani muscle, where there are no vessels, nerves or muscular fibres to be injured. The superficial fascia and deep fascia are divided, and the loose connective tissue behind the rectum exposed. The rectum is then separated on its posterior wall by a suitable instrument as high as the promontory of the sacrum. In the cavity thus made, a strip of iodoform gauze of four to six thicknesses is laid and the small external wound protected from the anus by an adhesive plaster or collodion dressing.

The reporter had extended the incision alongside the coccyx when necessary. When Sick says that no muscle fibres need be divided he loses sight of the fact that the levator ani must be cut through. With good retraction of the wound one can readily denude the posterior wall of the rectum from one side to the other with the finger and can make a wide denudation of the anterior wall of the sacrum well up into its curve. He did not use any instrument for a higher denudation, believing that that accomplished by the finger on the rectum and sacrum would be ample for a permanent cicatricial adhesion of the rectum to the sacrum. The opportunity afforded to the sphincter ani to recover its normal tone is probably an important

factor in the permanent result. He had not protected the wound from anal infection by an adhesive plaster or collodion dressing, but had in the recent cases, moistened with alcohol the gauze packed into the wound, and had depended chiefly, for protection against infection, upon the prevention by opium of bowel movements for four or five days when granulations have developed over the wound surface. The perfectly dependent drainage is also a very important factor in this connection. In no case has there been any disturbance from infection and in all cases the healing has been rapid. The first case presented was a boy, six years old, an imbecile, who was transferred to the surgical ward September 27, 1917, because of an almost constantly recurring prolapse of the rectum of about a year's duration. The mother says that when the child was at home the reduction of the prolapse was always difficult. On one occasion while in the hospital the prolapse was accompanied by "violent and profuse hemorrhage," but this ceased immediately after reduction. The Sick operation was performed October 13, 1917. Packing removed from wound five days after operation and wound not packed at all afterwards. It was completely healed in two weeks and there has not been the slightest recurrence of the prolapse.

The second case was a woman, fifty years old, an epileptic who had had a prolapse of the rectum for ten years, which protruded three to three and a half inches. At first the patient could reduce it herself, but is no longer able to do so. It comes down on every movement of the bowel and at time of operation, October 27, had been down for about forty-eight hours. The operation was performed under gas-oxygen anæsthesia, and because of the difficulty of keeping the prolapse reduced the operation had to be done without reduction, the prolapse being covered by a piece of gauze and the reduction being maintained afterward by the packing of the wound tightly with gauze moist with alcohol. Two silkworm stitches were employed to close the lower part of the wound. The packing was removed in a week. There were no signs of infection and the patient did not complain of any pain in the wound, nor of any tendency of the prolapse to recur.

DR. JOHN B. ROBERTS said that it seemed to him that this operation was adapted only to mild cases. About twenty-five years ago he himself had devised and performed an operation for prolapse of the rectum which was original. The first operation was done at the Woman's Hospital of this city. The method was described in the *ANNALS OF SURGERY* and in his "Modern Surgery." Other operators have since practised it satisfactorily. It is intended for severe cases of prolapse of the rectum with great dilatation of the anal aperture. The dilated orifice of the anus is reduced in diameter by cutting out a portion of the sphincter with the perineal skin at its posterior part. The skin incision, which is V-shape, has its apex at the point of the coccyx. By burrowing in the cellular tissue behind the rectum with fingers and scissors, the surgeon is able to reach the posterior wall of the rectum for a distance of several inches, thus sepa-

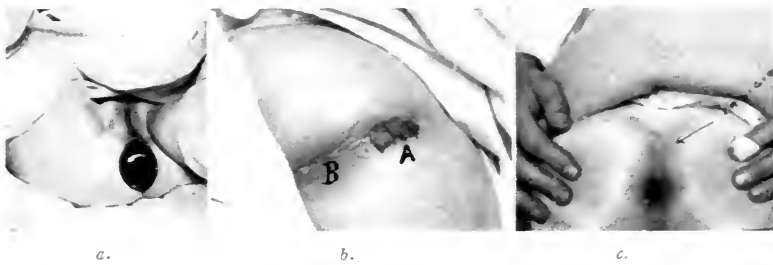


FIG. 1.—*a.* Case II. Before operation, showing prolapse of rectum. *b.* Case II. Two days after operation. A, gauze protruding from wound; B, anus—two silkworm-gut sutures between A and B. *c.* Case I. Scar in median line three weeks after operation. Complete healing in two weeks.



rating the gut from its attachment to the hollow of the sacrum. A sufficient V-shape portion of the posterior wall of the rectum is excised, the point of the cut-out V reaching several inches upward from the external opening of the intestine. After hæmostasis, the rectal wall is sutured from apex downward with chromicized catgut sutures and the stumps of the excised sphincter similarly united; after which the skin is closed back to the end of the coccyx, leaving, however, a space for the insertion of a drain. This excision of the rectal structures, by two V's with their bases together at the anus, converts the lower end of the intestine into a funnel-shaped tube and contracts the anus by lessening the diameter of the sphincteric ring. There is little opportunity, therefore, for the intestine to be thrust downwards and through the anus. The operation is intended for complete prolapse and is satisfactory for adults and even occasionally might be used in severe prolapse in children.

DR. GEORGE P. MÜLLER called attention to the paper of Lockhart Mummery, describing an operation similar to the Sick operation. Doctor Müller had operated four times by this method and knew that it was successful in all of them up to thirteen months ago. This operation consists of a transverse incision an inch long between the tip of the coccyx and anus. The rectum is separated from the hollow of the sacrum and the cavity is packed with gauze to produce adhesions of the posterior wall of the rectum to the sacrum. This is the simplest operation one can do in children with prolapse. In the case of one adult in which he did this operation there was recurrence. In adults he performs the operation of Moschcowitz and had operated thus on five adult patients, with cure in all, so far as he knew. One case occurred in a colored boy who had had the prolapse for twenty years. It was eight inches long and yet was easily pulled up and for the past two years has shown no sign of recurrence. The only trouble with this operation is the difficulty in doing it. The pelvis is so deep and, especially in the male, one has to reach far to the bottom of the pelvis to insert the first pursestring suture. In males also it is difficult to place more than two and sometimes three pursestring sutures. In the female it is easier because of the ability to use the uterus to obliterate. By plastic work on the peritoneum one can cover all the opening so that the intestine cannot herniate in any little pockets afterwards.

DR. THOMAS, in closing, said that it seemed to him that the reason that in children prolapse will so often disappear permanently without operation after the bowel has been kept up for a long time, is that the sphincter regains its control, and the severe tenesmus which caused the prolapse does not recur. He could not see that merely taking a piece out of the adult sphincter, long stretched, thinned and almost hopelessly paralyzed by the prolapse, and sewing the rest together is going to help much in preventing recurrence. If any operation could keep the prolapse up long enough to permit the sphincter to fully regain its normal tone, this secondary result would assure a permanent cure. The long and wide cicatricial adhesion provided by this simple operation, between the sacrum and rectum just where

the causal relaxation between them exists, ought to give the best possible support for this condition.

## NEPHROLITHIASIS WITH PERINEPHRITIC ABSCESS

DR. J. BERNHARD MENCKE presented a woman, twenty-one years of age, who ten months ago had an attack of severe right lumbar pain, which subsided after a few days. Two months ago she had a child. From the third to the seventh day after delivery she ran a temperature. When admitted she stated that she had suffered from pain referred to the right side of her abdomen for three weeks. Her temperature on admission was  $100^2/5$ . Leucocytes, 8,500. In the upper right quadrant of the abdomen extending into the loin was a tender nonfluctuating mass. X-ray showed numerous calculi in the right kidney. Cystoscopic examination by Dr. Tracey showed an œdematous right ureteral orifice surrounded by a zone of congestion. No urine obtained from the right side; normal on the left side. After preliminary treatment she was subjected to operation upon August 10, 1917. Lumbar incision opened an abscess cavity from which a number of calculi were removed. In the substance of the kidney proper there was an opening large enough to admit two fingers through which three more calculi were removed. Wound closed with tube drainage. Uneventful recovery. Eventual healing without sinus.

## APPENDIX IN SAC OF INGUINAL HERNIA

DR. J. BERNHARD MENCKE presented a man, twenty-two years of age, who had had a right inguinal hernia since infancy. It was now the size of a small orange when down.

When the hernia was reduced, the testicle also could be placed entirely within the abdominal cavity, apparently traversing a short inguinal canal. An examination of the blood having shown a normal coagulation time, operation was undertaken. Upon opening the sac its sole contents was found to be the appendix, the sac extending to near the base of the meso-appendix and the cæcum being far down back of the sac. An appendectomy was done. One testicle was found to be about one-half the normal size, the epididymis well developed. The testicle in its descent had come forward not as with a cord but with its peritoneal covering the wall of the sac flanging out to a broad base behind it. This was split and folded back, sacrificing the veins, and then the sac closed above and the hernial repair completed.

The convalescence was complicated by excessive oozing within the wound. This necessitated opening it superficially, closure being followed by primary union. The oozing continued for eight days, the coagulation time still being only three minutes. When the clot was evacuated capillary oozing was still taking place and a gauze wick inserted. Healing ensued and the ultimate result was good, although the testicle remained in the upper part of the scrotal sac.



FIG. 2.—Sequestrum showing complete necrosis of mandible.



FIG. 3.—Restoration of mandible after complete necrosis.





## NECROSIS OF THE MANDIBLE

### END RESULTS IN EXTENSIVE NECROSIS OF THE JAW

DR. J. BERNHARD MENCKE presented an adult patient who developed an infection after the removal of a left molar tooth. There followed, however, an osteomyelitis of the jaw. The case ran a protracted course and finally there separated several fragments which he presented. One fragment is about  $2 \times \frac{1}{2} \times \frac{1}{4}$  inches. The patient shows a good end-result, and illustrates the good outcome of a case treated with extreme conservatism.

### NECROSIS OF THE MANDIBLE: REMOVAL OF ALMOST THE ENTIRE BONE AS A SEQUESTRUM

DR. ALFRED C. WOOD presented a girl, aged fifteen years, who was admitted to the University Hospital, January 11, 1917, on account of swelling of the lower jaw and overlying soft parts. The trouble began twelve weeks before with severe "toothache" on the right side of the lower jaw. Subsequently ten abscesses formed, one after another, and opened spontaneously. Ten teeth were extracted at various times. The left side of the lower jaw was incised and a large amount of pus evacuated. At the time of admission the swelling was greatest about the symphysis; the mouth was very foul; there was no pain. The lower part of the face was greatly swollen, especially the chin; the swelling extending into the neck. The upper teeth were in fair condition. All of the lower teeth were missing. Almost all of the alveolar process appeared to be necrotic. The patient was able to take liquid nourishment only. Examination otherwise negative. Red blood-cells, 3,640,000; leucocytes, 23,300; hæmoglobin, 43 per cent. The urine contained albumin and a few hyaline casts. X-ray plates showed necrosis of both sides of the mandible, with an involucrum on the right side only.

The patient was ordered to use a mouth wash very frequently, and was sent home. She was readmitted July 16, 1917. The swelling of the face was much less and the general condition had greatly improved. The mouth was cleaner and could be opened more widely. The necrosed alveolar process was protruding through the mucous membrane throughout.

There was an external sinus at the angle of the jaw on the left side; X-ray examination showed necrosis of the entire lower jaw. The separation of the involucrum did not yet appear complete. She was therefore advised to continue the mouth wash and was discharged.

She was admitted for the third time October 4, 1917. The general appearance of the face had still further improved. The mandible was more exposed by extrusion through the mucous membrane. X-ray examination showed a complete regeneration of bone. Red blood-cells, 4,060,000; leucocytes, 8,320; hæmoglobin, 67 per cent. A trace of albumin and one cast were found in the specimen of urine examined. On October 13, under ether anæsthesia, the sequestrum was removed through the mouth. As Figs. 1 and 2 show, the specimen consists of the entire mandible, except the left articular process and a part of the ramus. The third molar tooth on the left side remains. Rapid improvement followed.

DR. JAMES K. YOUNG remarked that while the complete reproduction of the bone from any periosteum is a remarkable thing, the most extraordinary instance of it is the reproduction of the clavicle. The entire clavicle can be removed and, if the periosteum is preserved, it will be reproduced. All are familiar with the reproduction of the tibia, femur, and the long bones of the extremities; but, in the jaw and the clavicle this fact is often forgotten. Some years ago he exhibited to the Academy a patient in whom after the removal of the entire clavicle it had been wholly reproduced.

MAJOR DONALD McCRAE reported two cases of total removal of the scapula including the articular surface, with complete reformation and absolutely normal function. The size of the new shoulder blade was just about half that of the other one, but there was absolutely no difference in function. The humerus was entirely separated.

#### ACUTE DILATATION AND SPONTANEOUS RUPTURE OF THE STOMACH

DR. A. BRUCE GILL reported the history of a girl, aged sixteen years, who had been for eight years a patient and pupil in the Widener Memorial Industrial Training School for Crippled Children. She had at the time of her death a large fixed cervicodorsal kyphosis, and had been free from any acute symptoms of her disease for four to five years. On January 28, 1916, she complained of nausea following the use of atropine in the eyes for the purpose of refraction. The nausea passed away. On the following morning she had a similar experience following the second dose of atropine. She again soon recovered from the nausea, and seemed to be as well as usual, but she was kept all day under observation on the hospital floor, and her eyes were refracted in the late afternoon. At 7.00 o'clock the same evening she complained of pain in the upper abdomen and began to vomit. Her abdomen rapidly became markedly distended. The vomiting was persistent and her distention increased. No gas or fæces passed by the rectum. The nurse attempted to pass a rectal tube but was unable to enter it more than a few inches.

Doctor Gill saw the patient about nine o'clock. Her abdomen was then in a condition of very great distention, which was general and extended into the flanks and over Poupart's ligaments. Her pulse was 150, but of good quality. She complained of no particular pain except a feeling of tightness in the upper abdomen. Her respirations were not labored and she conversed without difficulty. At intervals she vomited without effort a few ounces of brown-colored liquid. There was no desire for a movement of the bowels.

A rectal tube was passed for a distance of twelve inches without the evacuation of any gas or fæces. While arranging for opening the abdomen, to determine the cause of the obstruction, the nurse came down and said that the patient attempted to turn over in bed and immediately expired.

The following morning a post-mortem examination was made. There was fluid and gas in the abdominal cavity. The small and the large bowels were collapsed. The stomach was partially distended, but a perforation

## HEREDITARY MALFORMATION OF THE EAR

was present in it on the anterior wall near the greater curvature about two inches below the cardiac end. The stomach contained a considerable quantity of liquid mixed with particles of food. Some of the food was identified as that which had been eaten two days previous. The stomach was nowhere adherent to surrounding structures nor did it present any evidence of ulceration. The mucous membrane was rent in several directions radiating from the point of perforation. The perforation itself was not more than an inch in length.

Evidently the patient had had a rapid formation of gas in the stomach, arising from undigested food which had been present in part for at least forty-eight hours. The stomach, for some reason or other, did not empty itself into the duodenum. It does not seem probable that the atropine placed in the eyes was sufficient to paralyze the involuntary muscles of the stomach. And yet the patient experienced nausea on both days after the use of the atropine. After the distention began the stomach could not empty itself into the bowels either because of pyloric spasm or because of a kinking at the pylorus due to the distention. As the patient lay in bed the pressure within the stomach was sufficient to force back through the cardiac end some of the large amount of fluid present in it, but none of the gas. Finally the wall of the stomach became so distended that the effort of turning over in bed caused it to rupture, with instant death of the patient.

On looking through the literature of the past twenty years, as recorded in the *Index Medicus*, he could find no case entirely similar to this one. As a matter of fact, there is but little literature on the subject. Hartmann, in the *St. Louis Medical Fortnightly*, 1906, p. 613, records the case of a woman who probably died of spontaneous rupture of the stomach. She had for three years been trying to reduce her weight by eating something and drinking vinegar, and the post-mortem examination showed extreme atrophy of the walls of the stomach. Paul Fraenckel, in *Deutsches Archiv für Klin. Med.*, 1906, lxxxix, p. 113, discusses a series of cases of rupture of the stomach following long repeated lavage of the stomach, and several following the administration of narcotics. Rupture of the stomach due to ulcer or carcinoma is, of course, excluded from consideration.

DR. JOHN A. BROOKE related the history of a somewhat similar case which was seen by him in a hospital in New York some time ago. The child in whom the rupture of the stomach occurred had been ill for some time and had been wearing a rather high hip spica of plaster of Paris. Following a severe attack of vomiting the child went into a state of collapse and died. The autopsy revealed a rupture of the stomach. It was thought that the plaster acting as a constriction may have had something to do with the rupture.

## HEREDITARY MALFORMATION OF THE EAR

DR. A. BRUCE GILL presented three patients, two brothers and their mother, who presented similar malformation of the ears, lop-ears. The mother states that her three sisters, her brother, her father, and her paternal

grandfather all had a similar deformity. There is here, therefore, an authentic history of lop-ear in four successive generations. In October, 1916, Doctor Gill operated upon the ears of these two brothers by excising an elliptical portion of skin and a half-moon-shaped piece of cartilage. As a result, the ears now lie fairly close to the skull. In these two boys the deformity of the ear is a stigma of degeneration, as both are mentally subnormal.

#### INGUINAL HERNIA COMPLICATED BY HERNIA OF THE OVARY AND TUBE

DR. GEORGE P. MÜLLER reported a case of a child five months of age who had been operated upon nine weeks previously for acute strangulation of the ovary and tube in a left-sided hernial sac. The ovary and tube were removed. Five weeks later her physician noticed a mass in the right side, and as it was feared that strangulation might also occur here Doctor Müller operated four weeks later, the child being then five months of age. Through the usual incision a hernia was found extending into the canal of Nuck, and in the sac was the right ovary and tube. These were gently replaced within the abdominal cavity and the hernia repaired in the usual manner. The child made an uninterrupted recovery.

#### FOREIGN BODY REMOVED FROM ABDOMEN NINE YEARS AFTER IT HAD BEEN SWALLOWED

DR. GEORGE P. MÜLLER reported a case of foreign body (pin) removed from the abdomen. The patient was thirty-four years of age. Nine years previously she had swallowed a pin, but thought no more of it. Three years ago she began to suffer from pain in the loin and right iliac fossa, together with frequency of urination. At the same time it was noticed that a prolapse of the uterus had occurred. In December, 1916, she was operated on by a surgeon for the latter condition. The operation was unsuccessful and the prolapse recurred. Her symptoms also persisted, and recently she submitted to an X-ray examination, and a stone was found in the lower pole of the right kidney and during the investigation of the ureter the pin was discovered at the level of the right sacro-iliac joint, and about on the course of the ureter.

Operation was performed by Doctor Müller on September 27, 1917. A loin incision was made and the kidney delivered from the wound. The stone was removed without a great deal of difficulty. A second incision was then made through the right rectus muscle and the peritoneum incised to the outer side of the cæcum and the colon and posterior peritoneum reflected from the abdominal wall. Just over the right iliac joint a mass was found which proved to be the pin, lying across, and in direct contact with, the ureter, surrounded by some exudate and containing some calcareous material. The pin and the exudate were removed and the cæcum stitched back into place. A tremendous mass of adhesions was noted in the lower abdomen, the result of the previous operation (probably a Hirst operation

## FOREIGN BODY REMOVED FROM ABDOMEN

through a Pfannenstiel incision). The patient made an uninterrupted recovery.

DR. ADDINELL HEWSON reported an end-result of a condition found in a cadaver. The patient had been an inmate of an insane asylum and there were found in her abdominal cavity seven hairpins. The condition presented was that apparently of a huge abscess extending from Poupart's ligament to the cartilage of the chest and confined to one side. Examination of the umbilicus showed it to be perfectly cribriform from the openings made by the introduction of the hairpins into the abdomen. Further examination showed that the abscess extended throughout the abdominal cavity, that there was an opening through the upper segment of the rectus muscle about 4 cm. in diameter and that the muscle was entirely eroded. Examining further, it was found that the hairpins, one at least, had gone completely into the intestine. The whole mass was one of intense inflammation with the intestines all bound together. One of the hairpins was entirely within the lumen of the intestine, apparently without doing harm. There was the history that at the institution in which the patient died she had been found in the act of driving these pins into the umbilicus. Some of the pins had not been divested of their shiny covering. They were the usual 2½ and 3 inch pins; some of them with the fluted margins and not absolutely straight.

DR. J. M. SPELLISSY said that Doctor Müller's report reminded him of an operation that he had performed years ago and in which the pre-operative diagnosis had hesitated between an inflammatory condition and a chondroma of the crest of the right ilium. Dr. G. G. Davis saw the case in consultation and advised exploration, as the result of which there was found at the bottom of a very deep extraperitoneal dissection a torpedo-shaped mass of lime salts having a pin as its nucleus. The incision was drained and before the resulting sinus healed the patient left St. Joseph's Hospital. Several months later he was readmitted, this time to the service of Doctor Davis, who, operating for the closure of the sinus, found that it terminated in a perforated appendix, which he removed, with subsequent healing of the abdominal wall.

DR. CHARLES H. FRAZIER said, at the risk of going too far afield into a discussion of foreign bodies found in the appendix, he would mention the case of a little girl upon whom he operated a good many years ago for appendicitis. Upon putting his finger through a small incision to take out the appendix he felt a pin prick. After having made the incision wider and, picking the appendix up with a pair of forceps, he saw a black rusty pin protruding half an inch beyond the lumen of the appendix. The child made an uneventful recovery. He referred also to the case of a well-known colored employe of the University who succumbed to pneumonia. The autopsy revealed a large rusty nail in the appendix.

MAJOR DONALD McCRAE said that a number of years ago a case was brought to him as one of appendicitis and with the history of having had several attacks. He made the usual incision and found the appendix quite normal. Of course, the appendix was removed, but a little higher up he found quite a little mass, and in separating this there was seen a rather in-

flammatory adhesion between the cæcum and a loop of small intestine from which he evacuated a few drops of pus and in the centre of which was a tooth-pick. The tooth-pick had perforated the ascending colon, made its way into the loop of small intestine, and was in position to pass out the other side of the loop. It was pulled out through the second opening in the wall of the intestine. The opening was closed, a cigarette drain inserted, and the patient recovered. It struck him that there might be no end of the wanderings of this tooth-pick, having seen it actually passing through the cæcum into the small intestine and headed for the other side. Nature had shut off the other end. Having almost seen the process taking place he could imagine how such a body might under certain conditions wander about in many ways.





FIG. 1.—Dislocation forward of sixth cervical vertebra.



FIG. 2.—Dislocation reduced



## CORRESPONDENCE

### BILATERAL DISLOCATION OF THE SIXTH CERVICAL VERTEBRA FORWARDS

EDITOR ANNALS OF SURGERY:

Having noticed in a recent number of the ANNALS an article on dislocation of the spine, I am sending you two remarkable X-rays of a case treated by me.

The patient, a woman, thirty-two years of age, was knocked down by a Ford car November 12, 1915. I saw her late at night on November 13, in the Sisters' Hospital of Salina, Kansas, with Doctors McCullough, Riddell and Miers. She had a moderate sized goitre and had had bronchitis for ten days. There was no notable deformity of the spine, but there was much cervical pain. Motion of the head was possible but painful. The urine had been drawn off with catheter and the rectum evacuated by enema.

*Right Lower Extremity.*—Can raise knee off bed. Can move the toes.

*Left Lower Extremity.*—Can rotate but cannot flex or extend thigh. No motion in toes. Sensation to light and heavy touch and to prick present. No zone of hyperæsthesia. An X-ray by Doctor Brittain showed a forward bilateral dislocation of the sixth on the seventh cervical vertebra (see Fig. 1).

November 14, under chloroform by Doctor Harvey, direct traction with the hands on the head was exerted and one distinct "click" was felt and heard in the neck which suggested that reduction had been obtained. An X-ray, however, showed that nothing had been accomplished. Further repeated efforts at manual traction also failed to give results.

The head was then passed through the hole in a strong laparotomy sheet, which gave a perfect means of counterextension. By means of towels and bandages loosely placed around the neck, it was possible for two men to apply powerful traction to the head. When this was done, we were rewarded by hearing and with the palpating finger feeling two distinct "clicks" in the spine. An X-ray showed that complete reduction had been effected.

Eleven weeks after the accident the patient weighed 135 pounds, having lost 25, and could walk 15 or 20 feet without assistance. She suffered some pain in the neck, shoulders and chest, especially during bad weather. Her arms and hands were weak.

On October 29, 1916, her husband wrote: "A great many people think Mrs. H. looks as well now as before the accident, but she lacks a great deal of being well. She has been doing the work at home for some months past, which, with our two children, represents a good deal of work. She gets along nicely with it, but tires easily. She is troubled with stiffness through her hips and back after sitting still any length of time, also when getting up in the morning. This trouble seems worse in cold weather."

JOHN FAIRBAIRN BINNIE, M.D.

January 5, 1918.

Kansas City, Mo.

## BOOK REVIEW

RECOLLECTIONS OF A NEW YORK SURGEON. By ARPAD G. GERSTER, M.D.  
8vo, cloth, pp. 347. New York: Paul B. Hoeber.

The author has given us in this book a charming record of his life work. It might also have been entitled "The Making of an American Citizen," for it is as an Austrian Medical Officer, on the Reserve List, that Doctor Gerster first comes to the United States in 1873, and as an American Medical Officer on the Reserve List that he completes the record forty-four years later.

We thank Doctor Gerster for giving us this book. It is most instructive and illuminating, as well as entertaining. Arthur Christopher Benson has well said in his essay on Books: "Almost the only books which I think it is a duty to read are the lives of great contemporaries; one gets thus to have an idea of what is going on in the world, and to realize it from different points of view." The alcove devoted to Biography, therefore, is the most important element of any library. To the surgeon there is a wealth of such material at his hand and he makes a grievous mistake if he neglects it. In magnifying the biographies of our contemporaries there is no thought of consigning to oblivion the life records of the great worthies of the more distant past. These will never cease to be the guides and models of the student and practitioner, but they are more set apart and clothed with a sentiment that ranks them above common mortals; feelings which we do not have when we read the records of our own companions or personal teachers, whose hands we have grasped and whose foibles, as well as whose virtues, we know. With what zest have we read Gross' Autobiography; Marion Sims' Story of My Life; Vallery-Radot's Life of Pasteur; Sir James Paget's Memoirs; William Thompson Lusk's War Letters, or John A. Wyeth's "With Sabre and Scalpel."

The picture which Doctor Gerster draws of his birthplace, the Hungarian town of Kassa, is quite idyllic. The royal free city of Kassa seems to have been an ideal *imperium in imperio*, a small republic sufficient to itself in its happy valley in the interior of Hungary. Alas, that these rights should have vanished almost at the time of birth of the author! We read with interest the references to the turbulent times culminating in 1848. We can readily appreciate that the same spirit which prompted the father to become an insurgent in 1848, also prompted the son in later years to choose as the field for his life work the Western Republic.

Any man who has played an important part in the affairs of his generation can well serve his fellows by leaving behind him such records of his own experiences, motives and accomplishments. LEWIS S. PILCHER.

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## THE CHLORINE ANTISEPTICS IN CIVIL HOSPITAL USE\*

BY JOHN A. HARTWELL, M.D.  
OF NEW YORK

ASSISTANT PROFESSOR OF SURGERY, CORNELL UNIVERSITY MEDICAL COLLEGE AND DIRECTOR OF SURGERY,  
BELLEVUE HOSPITAL

OUR conclusions after four months' intensive study at Bellevue Hospital with the chlorine antiseptics are:

1. The establishment of the Carrel-Dakin technic presents no undue difficulty.

2. The results obtained in the military hospitals abroad can be duplicated in general civil hospitals in dealing with traumatic cases.

3. These antiseptics are not as efficient in controlling spontaneous infections, *i.e.*, those not directly due to trauma. They are not as valuable in burns as other forms of treatment.

4. Reasonable care prevents skin burns in all circumstances.

5. Dichloramine-T in either chlorinated eucalyptol or chlorcosane—the chlorinated paraffin oil—is not a completely efficient substitute for the sodium hypochlorite solution.

1. The inauguration of this work at Bellevue Hospital was undertaken on the Cornell Division late in October. The College provided one nurse who had taken a course at the Rockefeller War Hospital, and also a laboratory worker to do the routine bacteriological work. Later, when we were asked by the Surgeon General's Office to undertake the teaching of Medical Reserve Officers, Captain E. F. Butler, who had been on the staff of the same hospital, was detailed to assist in this work. No other member of either the surgical staff or the nursing staff had any but a theoretical knowledge of the subject, except the writer, who had had a limited experience by operating upon and following a few cases at the War Hospital. The traumatic cases and all suppurating cases were taken out of the general service and assigned to the care of this small staff. The house staff and the regular nursing staff at first only help incidentally.

The impetus given the work by placing it on a military basis for teaching purposes was very great. Our first concern was to assemble the necessary supplies. This was entrusted to Captain Butler and Dr. Dudley, and when the ordinary routine of hospital requisition was too slow, the College stepped in and procured the supplies direct. The making of the hypochlorite

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\* Read before the New York Surgical Society on March 13, 1918.

solution was entrusted to Dr. Stanley Benedict, of the Department of Chemistry at the College. The Phipps Institute, in Philadelphia, furnished us with our early supply of Dichloramine-T and chlorinated eucalyptol. When, later, Doctors Dakin and Dunham had perfected the chlorcosane, these preparations were procured from commercial houses, as was the chlorasine from the start.

The preliminary preparations consumed less than one week. Suitable cases were then selected and placed under the care of the special staff of two surgeons, one nurse and the laboratory worker. As mentioned above, the regular hospital organization was only used incidentally in the general care of the patients, the only specific duty of the nurses being to see that the requisite flushing of the tubes was given at the stated intervals. In addition to this the head nurse in each ward was usually present at dressings in order to receive instruction and render the assistance ordinarily assumed by the nurse in charge. The members of the house staff were not at first included in the organization, as it was desired to master the details of the technic before entrusting it to inexperienced surgical judgment.

Much of our time had to be devoted to teaching the Medical Officers, so that not more than two to three hours daily could be charged to the actual care of the patients, who at most times numbered twenty-five to thirty. With the arrangements above outlined, we considered that we had the methods in satisfactory working order at the end of one month. The head nurses were gradually worked into the organization, and by this time had become proficient in the details. The routine care of the patients occupied no more time or assistance than by the older methods of treatment. After another month a junior member of the house staff was admitted into the organization, and at the end of two weeks was entirely competent to handle all the less complicated cases with the aid of the head nurse only.

The final result, after four months, is a perfectly running machine which operates with no more difficulty than is experienced in the running of any hospital organization where the service is heavy and rapidly changing, and where much attention is paid to teaching. The only difficulties encountered were in keeping our supplies always up to the standard and having the dressing carriages properly equipped. This arose, not from any inherent difficulties, but from a willingness to "make do" with whatever is at hand, rather than to foresee and prepare. Insistence on detail overcame this, and it was not long before everything was at hand when needed.

The methods employed are thus given in order to show that with proper organization and a willingness to follow the details as worked out by Carrel there is no reason to prevent the application of the Carrel-Dakin technic in any well managed hospital service. It would not have been so easily accomplished with us without the aid of Captain Butler and the special nurse, Miss Gorman, because previous practical experience would have been lacking. This lack, however, would only have delayed the consummation of our plan, because the literature gives all needed information and daily experience overcomes the difficulties. We relied explicitly upon the descrip-

tions given by Carrel and accepted without question his methods, making no attempt to either improve them, modify them or substitute short cuts. Our desire was to test the question by exact duplication.

2. The statement that our results duplicate those reported from the war zone is, of course, based upon a comparatively limited number of cases. These included compound fractures, traumatic amputations and severe lacerations of the soft tissues. They were received into the hospital in all three stages, *i.e.*, contaminated within the first six or ten hours after injury; infected after six or ten hours, up to twenty-four hours, and suppurating after twenty-four hours to three or four days. In no case falling in the first stage, no matter how severe the injury, was there any subsequent suppuration. A compound T-fracture of the femur into the knee-joint, operated on eight hours after receiving the injury, was the most severe of this group. Recovery was slow, but took place without suppuration. The most difficult to cope with, however, were severe lacerations involving the dense tissues of the sole of the foot and the palm of the hand in laboring men. The unusual preponderance of fibrous tissue, subcutaneously, and the near coincident injury of the palmar and plantar fasciæ possessing low bacteriological resistance required the closest attention to prevent suppuration and the longest time to obtain surgical cleanliness.

In the second group—infection already being actively started—we were not able in all cases to control it without the suppurative stage developing. This was best illustrated by a border-line case between the first and second stages. The patient was admitted with his left arm nearly avulsed from the body, so far as the soft parts were concerned. There was also a badly comminuted compound fracture into the elbow-joint. The brachial artery was torn completely across at the profunda branch and many of the muscles of both the forearm and arm were literally shredded. He refused amputation. All lacerated tissue was removed, and thorough mechanical cleansing of the traumatized area accomplished. The tubes were placed and instillation of the hypochlorite solution carried out. Active evidence of infection was absent for nearly seventy-two hours. When the hand and forearm showed gangrene from lack of blood, the patient consented to amputation. During the period from evident gangrene until amputation was done, the infection developed rapidly and in the devitalized tissue was not in the least held in check by the treatment. It extended upward along the torn muscles of the shoulder girdle. Disarticulation of the shoulder was done, and tubes placed in all open spaces. The infection, which had now developed to the suppuration stage, was rapidly controlled and in one week the surfaces were all clean and healthy granulations covered them. There continued, however, a high bacterial count from the glenoid fossa. This could not be lowered by the most careful instillation of the hypochlorite solution.

Here was demonstrated a fact often seen, namely, that the bacterial count is the only true indication of proper progress. There was no active suppuration, and from a clinical standpoint surgical cleanliness seemed to

be present, but healing was slow. About two weeks later, under anæsthesia, the glenoid was exposed and the cartilage showed necrosis. The cartilage was removed and prompt lowering of the bacterial count resulted with rapid healing. The hypochlorite solution will not, in the presence of virulent infection, always prevent necrosis in such poorly nourished tissues as cartilage, fascial expansions, etc. This was found true in other cases.

Our success in treating the third stage, where active suppuration following trauma was established before the patient came under our care, was equally satisfactory with those in the earlier stages. There was, in this stage, no case with severe compound fractures or joint injuries, so that we were not put to any severe test. Two cases, however, gave potentially grave prognoses.

The first was a crushing laceration of the dorsum of the foot which had been sutured by the ambulance surgeon. The patient was received into the ward with a fulminating infection causing gangrene in the skin around the wound and extending well up the leg, and a high grade of lymphangitis and femoral adenitis. All acute symptoms were under control in forty-eight hours, and the granulating area was grafted successfully on about the fifteenth day.

The second case could give no account of his injury, but there had been a circular twisting violence of the muscles of the inner and anterior aspect of the thigh, with an extensive laceration of the skin. This, too, had been sutured, and was admitted with active suppuration. The muscles were torn from each other and from the femur; the vastus internus was torn almost completely across; the vessels were exposed, but not damaged; a severe suppuration had spread throughout the entire traumatized area. At operation the skin wound was enlarged, the hopelessly damaged muscles and effused blood removed and tubes placed in all parts. Suppuration was controlled in forty-eight to seventy-two hours and healing had begun.

A third case belonging to this general group was admitted from the erysipelas ward with extensive suppuration beneath the pericranium, involving practically the entire vault. The scalp tissues were so badly devitalized as to threaten gangrene. Incision and the instillation of the hypochlorite solution promptly controlled the suppuration and averted gangrene. It, however, did not prevent a recrudescence of the erysipelas. Final recovery was complete and the denuded ivory bone seen at first threw out granulations and the pericranium again became attached to it. The control of the suppuration and saving of the scalp may be credited to the hypochlorite solution, but the convalescence was very protracted.

3. The statement that spontaneous infection from within, not directly due to trauma, is not as efficiently controlled by the chlorine antiseptics is based upon observation of chronic osteomyelitis, suppurative tenosynovitis, empyema, abscess of the lung and abscess of the liver. In such conditions one is dealing with a very different pathological process, in that the infecting organisms are more or less deeply placed in the surrounding inflamma-

tory zone. The hypochlorite solution rapidly clears away the suppuration and digests off all necrotic tissue, but one cannot see that the deeper processes are more rapidly attacked than with simple efficient drainage and daily dressings. There were a large number of cases with advanced purulent tenosynovitis admitted to the service and the results in these were particularly disappointing. It is true that most of the cases doing badly were chronic alcoholics, with more or less advanced degenerative changes and correspondingly lowered resistance. The empyemata treated with the usual operative procedure and then washed periodically with the chlorazine solution, .5 per cent., by means of Carrel tubes placed in all parts of the cavity, did well, but the progress did not seem more rapid than by other methods of treatment. Our conclusion that the non-traumatic suppuration is not as effectively dealt with as the traumatic is not susceptible of actual proof, but it represents the opinion of all those observing the cases.

In burns we were unable to demonstrate that the chlorine antiseptics were of especial value. They were used in comparison with the paraffin treatment and the older forms of treatment. The hypochlorite solution causes too much pain to be practicable. The dichloramine-T failed to control the superficial suppuration, and it could not be seen that epithelization was unusually rapid. It has been fully demonstrated that the chlorine antiseptics are not bactericidal to the bacillus pyocyaneus, and burn infection is often contaminated with this organism.

4. In no instance were we troubled with skin irritation as the result of the use of the hypochlorite solution, except that in one or two cases a superficial irritation was caused when the solution found its way under a tightly applied retention dressing. The technic as described by Carrel for the prevention of burns was carefully adhered to. Much has been said of the difficulty and tediousness of carrying out this part of the procedure. Our experience does not substantiate this view. Vaseline gauze, if properly prepared, and the skin thoroughly dried, is applied with no difficulty, and is not unduly time consuming. In most instances, after the first three or four days, the vaseline gauze does not have to be changed oftener than every second day, and sometimes not so frequently.

As stated above, the solution used by us was prepared in the college laboratory by Mr. Emil Osterberg, under the direction of Dr. Stanley Benedict, professor of chemistry. We believe that this fact had very much to do with the success of our work and the absence of irritating effects. This solution would remain at the standard strength for several days, or even weeks, and its titration in the general supply, the irrigation jars and the tubes, practised at regular intervals, showed no deterioration and no change in its reaction. This is quite contrary to the experiences of those who have attempted to use Dakin's solution as made up in the hospital pharmacies. It is quite possible that a greater chemical skill is required to properly standardize the solution than is implied in the published description of its preparation. At any rate, the laboratory was able to furnish us solutions

which remained unchanged for a period of four weeks to four months, without any especial protection from light or other deteriorating conditions.

We are permitted to report that Doctor Benedict has perfected a modification of the preparation of Dakin's solution in which sodium chloride instead of bleaching powder is used. This method is far simpler than the older method, or that in which the chlorine gas is used, and results in all instances in a standard strength solution with a variation of not more than one-tenth of one per cent. A published description of this will appear in the near future.

5. The *Dichloramine-T* was used at first dissolved in chlorinated eucalyptol, and later in chlorcosane—a chlorinated paraffin oil. We were not able to demonstrate that these preparations were able to so completely control infection as the hypochlorite solution. Furthermore, the granulating surface resulting from their use was less healthy and less adapted to secondary suture or skin grafting than were the surfaces after the hypochlorite solution. In the use of the chlorcosane there was also a tendency for the heavy oil to prevent the advancing epithelium from the edges of a wound adhering to the granulations. It was not unusual to find a film of living epithelium extending out over the granulations for a distance of  $\frac{1}{2}$  cm. or more, without becoming attached to them. In doing grafting and secondary sutures it was found necessary to very carefully remove this oily film in order that adjacent surfaces would properly grow together.

We did not feel justified in attempting to use the dichloramine-T spray in extensive complicated wounds of the soft parts or in compound fractures. This attitude was taken because it seemed impossible to procure one of the essentials of antiseptic treatment, namely, contact. With a little practice Carrel tubes can be so placed that one is practically certain of bringing the Dakin's solution into recurrent contact with every portion of any wound. This we were not able to see any method of accomplishing with the dichloramine-T in deep lacerations extending into the muscles, bones and joints. It is only fair to say, therefore, we possibly did not give the remedy as complete a trial as we did the Dakin's solution, and with further experience we may feel more willing to use it in this type of case. In one such case, a severe suppuration in the muscles of the calf occurring in a diabetic patient, the Dakin's solution and the dichloramine-T were both used over different periods, as was also done in a widely opened chronic osteomyelitis of the tibia. In neither of these cases was it possible to keep the bacterial count down to a point of surgical cleanliness with the dichloramine-T, and its use had to be abandoned in favor of the Dakin solution.

In summarizing we feel that our four months' experience has satisfactorily demonstrated the practicability and the advantages of using the Carrel-Dakin treatment in those civil hospitals where a considerable number of traumatic cases are treated. It is interesting to note that its practicability and advantages have been accepted by the Surgeons General of the British Army. Sir Anthony Bowlby ("The Development of British Surgery at



the Front," *British Medical Journal*, June 2, 1917) and Sir George H. Makins ("The Development of British Surgery in the Hospitals on the Lines of Communication in France," *British Medical Journal*, June 16, 1917) state emphatically that this treatment has demonstrated its superiority over others. It is now used in the British Casualty Clearing Stations, and provision has been made for its continuance on the hospital trains and the hospital ships, so that the wounded receive the benefit of it continuously until received into the base hospitals. This, in view of the earlier skepticism of the British, is strong testimony in its favor.

In those civil hospitals where a traumatic service is not an important part of the hospital work, it is doubtful whether the inauguration of this treatment will meet with great success, for the reason that the call for its use will not be frequent enough to make it an established routine. Without this, it probably would be no more effectively applied than is any other special form of treatment which is only occasionally demanded in a general hospital service, and if ineffectively applied it cannot be expected that satisfactory results will follow.

## BISMUTH PASTE IN WAR SURGERY \*

ITS USE IN COMBINATION WITH THE SKIN SLIDING OPERATIONS FOR CHRONIC  
SUPPURATIONS AND LUNG ABSCESS

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MILITARY surgeons serving at the front inform us that there is a rapid accumulation of chronic suppurative cases in Europe, although everything possible is done on the battlefield and in the First Aid stations to prevent their occurrence. Guillot and Woimant<sup>1</sup> who recently published their experiences with infected fractures in the French base hospitals state that probably 50 per cent. of all fractures of the thigh still suppurate after ten months of treatment.

Disinfection of a wound an hour after the injury by an orderly is more efficient than the most scientific treatment two or three days later, if such primary disinfection is not practised. The principal factors in the prevention of chronic suppuration now considered are: The prompt and complete excision of the infected area, as practised now in the field hospitals, and Carrel's ingenious method of flushing the wounds with hypertonic solutions. If it were not for these, the hospitals of Europe would be unable to care for the enormous number of suppurative cases which would accumulate. Besides, the economic waste due to loss of men, to invalidism, and to dressings would be most disastrous. It is, therefore, very timely and imperative that we prepare ourselves to receive and to treat these cases of chronic suppurations with the most efficient methods at our disposal.

With this aim in view, I desire to offer some suggestions in the treatment of those cases in which the methods of prevention have not been effective and persisted in discharging pus. These suggestions are based on an experience gained in treating about 2000 chronic suppurative cases. Although most of these were chronic discharging sinuses resulting from tubercular bones and joints or post-operative suppurations, the treatment here outlined will be quite as effective in the chronic suppurations produced by war injuries, since the late conditions in both instances are nearly identical.

It has always been a problem how to deal with this class of cases. Only during the past ten years has any real progress been made. Until then, almost every form of treatment which had been tried was found lacking. Cases were repeatedly operated, then irrigated by various solutions, such as permanganate of potash, weak solutions of iodine, silver nitrate, etc., and after these procedures have all been tried alternately and in time found inefficient, the patients usually became reconciled to daily dressing, giving up all hope of ever being cured.

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\* Read before the Academy of Medicine, Cincinnati, March 11, 1918.

<sup>1</sup> Surgery, Gynecology and Obstetrics, November, 1917, p. 507.

Ten years ago we (my brothers and I) introduced a new method of treatment of this class of cases; namely, the injection of "*bismuth paste*."<sup>2</sup> It is unnecessary here to repeat in detail the theoretical aspects of this method. By this time the bismuth paste method of treating chronic suppurations is well known and its efficacy recognized. After ten years' use in almost all parts of the world, it has retained its place and is now employed more extensively than ever. Reports in the literature indicate that approximately three out of four cases of the very old neglected suppurative sinuses may be cured by this simple procedure.

Many surgeons and physicians have the impression that the use of bismuth paste is confined to tuberculous sinuses following bone and joint affections. I wish to correct this false impression by stating that the bismuth paste has been applied successfully in the treatment of all chronic suppuration from whatever source in practically any part of the body. The post-operative fistula of the abdomen, the nasal accessory sinuses when affected with chronic suppurative disease, and even fecal and genito-urinary fistulae have yielded most readily to this form of treatment. But the most favorable results in my experience have been obtained in infected wounds after crushing injuries of bone and soft tissues.

This experience leads me to advise its use in war surgery, where the majority of wounds are infected before they reach the base hospital. I was recently informed by Doctor Carrel that the method was employed at the French base hospital at Compiègne in 1916 with satisfactory results, with material and instruments I sent him at that time. Doctor Richter, in charge of one of the Red Cross units which for a time worked in a German base hospital, also used this method of injecting suppurative wounds resulting from shrapnel, gunshot and bayonet, and reported most satisfactory results.

During the past year there appeared in *The London Lancet* a number of articles on the use of B. I. P. P.,<sup>3</sup> the first article being written by Rutherford Morrison,<sup>4</sup> August 12, 1916. His formula differs from mine in that he has added iodoform, and, instead of using vaseline, he uses liquid paraffin. The results obtained by him and by others who have used this paste indicate that the floodings of sinuses with bismuth mixtures of various combinations is a most effective treatment of infected wounds. I have, as yet, had no experience with the formula which Morrison advocates, but since he applies it in the acute forms of suppuration, it may have some advantage in this class of cases.

The principal factor in obtaining good results with any of these flooding mixtures is "*correct technic*," and since experience in their application

<sup>2</sup> Beck, E. G.: A New Method of Treatment of Sinuses and Fistulae. *Journal of the American Medical Association*, March 14, 1908.

<sup>3</sup> Which is an abbreviation for bismuth, iodoform, paraffin paste.

<sup>4</sup> Rutherford Morrison: Treatment of Suppurating, Infected War Wounds. *The Lancet*, August 12, 1916.

teaches us many points, I believe it might be of value to those who use it, as well as to those who contemplate using it, to have pointed out to them technical errors which are usually committed, leading to poor results, and then to have an outline of the practical application of the bismuth paste in war surgery.

Technical errors usually committed:

1. The method is applied indiscriminately, without control by radiograms.
2. The mixture, when injected, is not sufficiently liquefied to fill all the sinuses and suppurating cavities.
3. The bismuth is applied in cases in which either a sequestrum or infected foreign body is at the bottom of the trouble.
4. The injections are often kept up after the wound is sterilized and thus no chance is given for healing.
5. The instruments used are often improvised and unsuitable.
6. The bismuth mixture is very often spoiled by the accidental admixture of a few drops of water. (Syringes should be perfectly dry when used.)

The following technic should be followed as closely as possible:

1. Preliminary to the treatment a set of stereoröntgenograms of the affected region is taken, to make sure that there are no foreign bodies or sequestra present. If such were present, they might be overlooked after the bismuth had been injected, because the shadows produced by the bismuth would obliterate the shadow of the foreign body.

2. Bacteriologic examination of the secretion is the next step. Smear preparations, cultures, and, in some instances, inoculation of guinea-pigs are made.

3. The wound is now ready for injection. The skin surrounding the wound is washed with alcohol and the tip of the glass syringe, which has been filled with the liquefied paste, is placed firmly against one of the drainage openings connecting with the wound, and the paste slowly but firmly forced into its channel until it is seen to escape from the nearest opening. Then the finger is quickly placed against this opening to prevent the escape of the paste, and the injection is continued. If there are many openings, an assistant must occlude all of them with his fingers during the injection, in order to be certain that all the branches of the sinuses have been filled. If there is merely a large suppurating cavity, it may be packed with gauze strips which are saturated with liquefied paste, and the injections may be carried on when the cavity has contracted down to a sinus.

4. After the injection another set of stereoscopic röntgenograms is taken, which give a clear picture of the entire network of sinus tracts and sometimes are the means of tracing the path to the focus from which the disease originated.

5. A sterile bandage is then applied and the patient put to bed for a few hours or a few days, depending on the severity of the case. In subsequent treatments the patients are usually allowed to walk about immediately after the injection.

6. The first dressing is done the following day. If the discharge which before the injection was creamy or profuse, has changed to a serous consistency, it is to be regarded as a favorable sign, and a microscopic examination will usually prove it to have become sterile. If the discharge is sterile, the sinuses need not be reinjected unless they later become reinfected. It is not intended that the paste remain in the sinuses. It will gradually exude, and within a week only traces may be found by fluoroscopic examination or by röntgenogram.

7. Should the discharge persist and remain purulent, the injections should be repeated at intervals of from five to six days for a reasonable length of time (from four to six weeks), and if after this period there is no appreciable improvement, one must search for the cause. A sequestrum may be present, or the focus of the suppuration be inaccessible to the paste, as, for instance, in the cancellous structure of long bones. In such cases, either the foreign body must be removed, or, as the case may be, the infected cancellous structure of bone curetted, and the bismuth injections resumed.

I illustrate herewith the instruments which are commonly used in my work (see Fig. 1).

I am convinced that with the proper application of this method we will be able to cure at least 75 per cent. of all the chronic suppuratives. For the remaining 25 per cent., which are usually considered practically hopeless, I shall suggest a surgical procedure which in my experience has been so effective as to justify our expectation of eventually being able to cure nearly all chronic suppurations.

In discussing the method in its application in special cases we shall divide the subject into two parts: (a) The treatment of *empyema and lung abscess* after prolonged drainage. (b) The treatment of *chronic suppurations* resulting from injuries in other parts of the body.

#### (A) EMPYEMA AND LUNG ABSCESS

After an infected wound in the chest has produced either a lung abscess or an empyema and has been properly drained, and has in spite of the most painstaking treatment failed to close, the problem becomes a difficult one. The patient, in the hope of final recovery, persists in dressing his chest wound once or twice a day, being well enough to perform some light work. Whenever his health suffers he becomes so discouraged that he is willing to submit to any operation which will either cure him or commit him to his grave. In this class of cases the bismuth paste has been found to be of the greatest value.

Doctor Ochsner, Chicago, reported to the American Surgical Association on June 4, 1909, 14 cases of empyema, all of which had been operated (two by Estlander's operation), with sinuses in all cases persisting nevertheless. He applied the bismuth paste in each of these cases, with the result that 12 cases healed completely and two were still under treatment at the time and very much improved. Others have reported equally good results. In my

own series of 110 cases, approximately 80 per cent. were cured by the bismuth injection treatment alone.

The procedure is as follows: Subsequent to a physical examination a stereoscopic röntgenogram of the entire chest (plate size 14 × 17) should first be taken.

After the pathological condition is ascertained and cultures of the discharge taken, the cavity is injected with a 10 per cent. bismuth-vaseline paste (bismuth subnitrate, 10.0; vaseline, 90.0).<sup>5</sup>

When the cavity or sinus is completely filled with this mixture, another set of stereoröntgenograms is taken. This set will illustrate the exact size of the cavity and its relation to the ribs and other structures in the chest. Whenever a communication with a bronchus exists, the patient will at once cough up the excess quantity of paste.<sup>6</sup>

The cavity may hold as much as 600 grammes, but from 100 to 200 is the average. See Fig. 2a, which gives a definite outline of the cavity filled with air before the injection, showing the thickened pleura covering the contracted lung, thus dividing the left chest into two almost equal sections.

The second röntgenogram (Fig. 2b) shows the cavity entirely filled with bismuth, and plainly defines the inner boundary of the cavity to be formed by the thickened pleura. The sizes and shapes of these cavities vary so much that there are no two cases alike. Sometimes we find a small globular sac communication with the outer chest wall by a long tortuous channel, and then again we find that there exists merely a long sinus without any cavity whatsoever. The stereoscopic effect permits us to estimate with considerable precision the depth of the cavity and its location.

The first injection does not always produce healing. In some cases repeated injections during several months are required, but these should be discontinued as soon as the discharge changes from a purulent to a serous character. Only when the discharge continues to be purulent should we consider radical procedures.

For illustration I shall cite just one case, which is a type most commonly encountered. Space prevents my illustrating more cases, and I refer the reader to my previous publications for further knowledge on this subject.

*Empyema: Eighteen months' suppuration.* Laborer, aged thirty-one, entered hospital November 17, 1917, with a profusely discharging sinus in the left anterior axillary line. Operation for empyema had been performed eighteen months previously and suppuration continued ever since. Treatment with various irrigations and injections, including paraffin oil, by his surgeon were of no avail.

<sup>5</sup> In former years I employed a mixture containing 30 per cent. bismuth subnitrate, but found that the above mixture produces equally good results and is not likely to cause bismuth absorption.

<sup>6</sup> A word of caution is here necessary: The patient should be warned not to take a deep inspiration during the injection. He is apt to inhale (through the existing opening of a bronchus on the infected side) some of the mixture and force it into the bronchus of the opposite side.

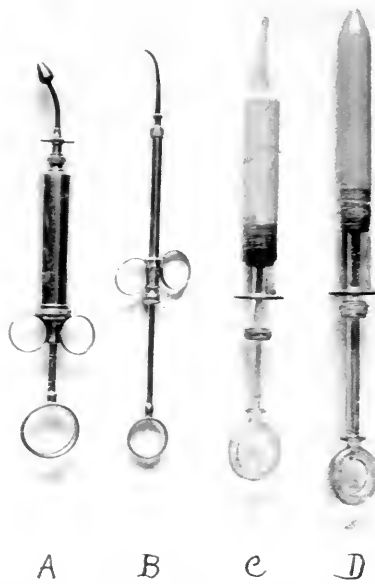


FIG. 1.—Instruments necessary for correct technic: *A*, metal syringe for small sinuses; *B*, metal syringe for stitch abscess; *C*, glass syringe for rectal work; *D*, glass syringe for all other work.

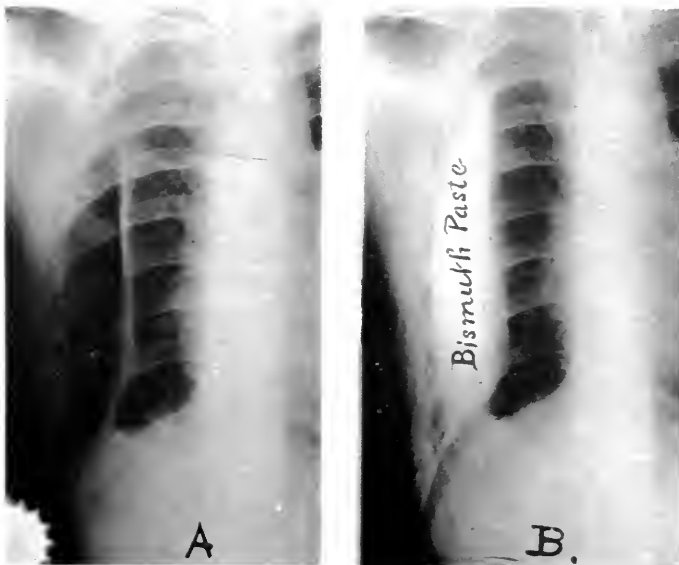


FIG. 2.—Empyema injected with bismuth paste. *A*, empty pleural cavity; *B*, cavity injected with bismuth paste. Note the thickened pleura dividing the lung from the empty space.

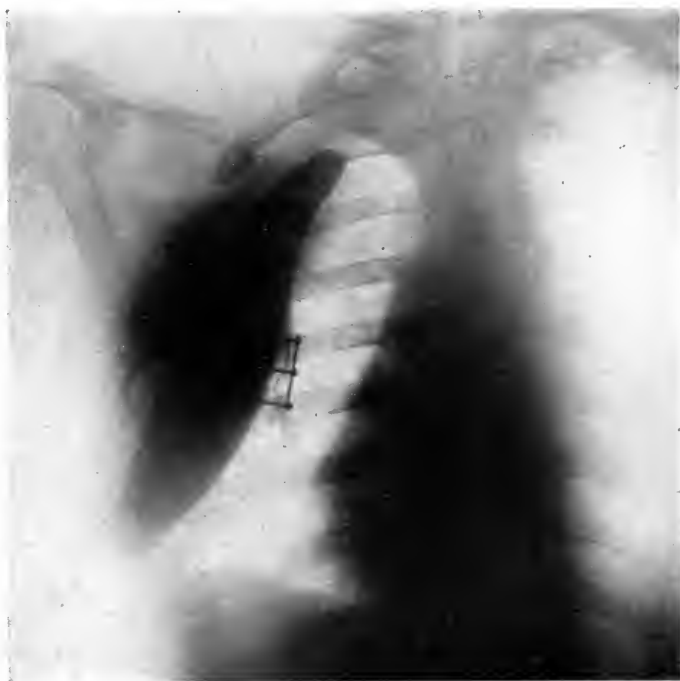


FIG. 3.—Lung abscess in upper lobe injected with bismuth paste.



An injection of six ounces of bismuth paste into the sinus filled the chronic empyema cavity which existed in the upper part of his chest (see Fig. 3).

The secretion, which was purulent and contained various types of organisms before the injection, was found to be serous and sterile twenty-four hours later. The sinus closed within four days and has remained so to date. Patient gained in general health and returned to his usual work.

We have tried to ascertain why some cases respond to the bismuth treatment and why others do not, and have come to the conclusion that whenever the cavity holds more than 200 grammes it will be less likely to heal by the bismuth paste injections. Cases which communicate with the bronchi are also more resistant than simple empyema.

Some cases heal shortly after the injection and remain closed for a year or two and the patient may be in good health, often gaining as much as thirty pounds, and then the sinus may reopen. The injections are then to be repeated. Closure usually follows for another year or two, and another relapse may follow at the end of that period. The patient often prefers to keep on treatment in this way, not being much inconvenienced and perfectly well in the intervals.

But there remains a small number, about one in five cases, which have no tendency whatever to heal under any form of treatment, and these require the most radical surgical procedure.

The methods in vogue in dealing with these refractory cases are known as the Estlander, the Schede operation, or the decortication of the lung. The patient who has to submit to one of these extensive surgical procedures is, of course, in a desperate situation. He is told that the operation causes a high mortality and that the surgeon cannot promise him an absolute cure. Aside from that, the surgeon must warn him of the prospect of a considerable deformity of his chest, whether he be cured or not.

*Sutureless Skin Sliding Operation for Lung Abscess and Empyema.*—During the past seven years I have employed a surgical procedure in these cases which I believe is less dangerous and quite as satisfactory as the Estlander or similar operations. Here I shall only make brief reference to this method, and refer those interested in this procedure to a publication in the *Journal of Surgery, Gynecology, and Obstetrics*, March, 1918.

The aim of this operation is to transform the abscess cavity into one lined with skin. To accomplish this the following procedure has been found effective:

Skin flaps, one to four in number, are made from the skin of the chest wall overlying the lung abscess or empyema. After the resection of a sufficient number of ribs over the lung abscess, which has first been localized by means of stereoröntgenograms, the abscess cavity is widely exposed, cleared of any contents, and the skin flaps are shifted into the depth of the cavity and kept in contact with the abscess wall by packing gauze tightly against the flaps. No suture material whatever is used to diminish the

size of the wound. In fact, the wound should be spread as far as possible. In forty-eight hours these flaps usually have become adherent to the abscess wall. The packing is removed, bismuth paste is injected, and the cavity repacked with gauze.

Epidermization will take place from the edges of the implanted flaps and in a reasonably short time the entire cavity will be lined with true skin, thus converting a fibrous suppurating sac into a dry cavity lined with skin, continuous with the skin of the chest wall.

In order to accelerate the epithelial growth from the skin edges, we have employed adhesive plaster strips, pasted in such a manner as to partly cover the edges of the true skin and of the granulating surface.

The denuded surfaces from which the skin flaps are taken are simply covered with gauze and these will gradually epidermize on the same principle as those of the flaps within the cavity.

In cases where one or more bronchi open into the lung abscess, the same may be closed by destroying the mucous membrane within the lumen of the bronchi by cautery, either at the time of operation or subsequently. This operation has been performed in seven cases, with very satisfactory results.

The logic of this surgical procedure consists in transforming the abscess cavity into a surface lined with skin. The cavity thus lined with epithelial covering will gradually diminish in size until the skin practically is outside of the cavity, the underlying tissues will gradually expand until the skin is pushed out to the surface of the body and there will be less deformity and a more satisfactory result in every way.

#### (B) CHRONIC SUPPURATIONS AND SINUSES DUE TO CRUSHING INJURIES AND GUNSHOT WOUNDS

Whenever the early treatment of these infected wounds has not been effective and chronic suppuration persists, there is either an infected foreign body or bone sequestrum at the bottom of the lesion, or the infection has penetrated into regions into which the disinfectant cannot penetrate or which cannot be reached by surgery. The traumatic cases have a tendency to spontaneous cure—first, because the patient's general health is usually much better, and, second, the infection is local and accessible to effective surgery, while those produced by chronic diseases have sinuses leading from inaccessible regions. The traumatic type for this reason also yields more readily to the treatment of injection by bismuth paste.

Guillot and Woimant<sup>7</sup> present a valuable contribution to the subject of early sterilization of infected wounds and late suppurations. They advocate first the Carrel-Dakin method of sterilization, sometimes followed by injections of different combinations of paste. They give preference to the bismuth paste, having observed no toxic effects and obtained good results. They advocate after sterilization of the wound the implantation of fat and suture of the wound. Those who have studied their reports and ob-

<sup>7</sup> Surgery, Gynecology and Obstetrics, November, 1917, p. 507.

servations and will compare them with those contained in this article will observe the essential difference to be as follows: *They advise the suture of the wounds, while I do not.* They use irrigation preceding the paste injection, while I omit all flushings. I do not advocate the suturing of the wound because this locks up the paste mixtures, which, after all, are foreign substances and may lead to absorption and poisonous effects. We have not practised the flushing of sinuses with watery solutions for many years and have obtained very good results without it. It should, therefore, be established by those who use flushings and the paste afterward whether the use of the paste alone would not accomplish as much.

As to the choice of the different pastes which are now being employed in war hospitals, I do not venture to dogmatize. I have now employed the bismuth-vaseline paste for ten years with gratifying results and have found no reason to employ new mixtures. This, however, does not preclude the possibility of an improvement, and I shall be pleased to adopt any other combination of paste as soon as I am convinced that it is superior to the bismuth paste.

The B. I. P. P. mixture advocated by Rutherford Morrison, of England, is said to produce very favorable results. I used the combination of iodoform and bismuth when I first introduced the method about ten years ago,<sup>8</sup> but on account of its odor, to which the patients objected, I had to discontinue it. I have found no difference in the results since its discontinuation. I would, however, warn against the closure of the wound after the iodoform or bismuth mixture has been injected. Iodoform is even more toxic than bismuth. Fortunately, we are able to avoid bismuth intoxication.

It is, of course, essential that sequestra should not be allowed to remain in bone cavities, otherwise the bismuth paste treatment will not be effective.

I consider the injection of bismuth for diagnostic purposes in these cases most essential, and at the same time enter a protest against the use of the probe as a diagnostic instrument. The probe is very misleading when we wish to ascertain the depth of sinuses or bone cavities. One needs only to glance at one of these radiograms in which the sinuses have been injected (Fig. 4) to convince himself that the use of the probe in ascertaining the course of the tract borders on the ridiculous. The tip of the probe may be resting in the nearest pocket or recess of the tract, and leave us under the impression that we have reached the bottom, whereas there may be a network of sinuses into which the probe can never be introduced. In fact, the sinus at times may be twice as long as the probe itself.

Curettage of the bony cavities without ocular inspection is likewise inefficient, especially if it is done blindly by introducing the curette through the sinus opening and scraping in all directions. Such a procedure is mere guesswork. No one can know whether he has reached all the diseased areas. Many times I have convinced myself of this by exposing the cavities which I had curetted and found that I had curetted in the direction of healthy bone and left the most diseased area untouched. Even exposure of

<sup>8</sup> Illinois Medical Journal, 1909.

the bone cavity and a very thorough curettage of every crevice under ocular inspection does not always prevent the recurrence of the suppuration. The customary procedure, for instance, of curetting the shaft of the femur, introducing a drain at one end and sewing the skin over the wound, will, in most instances, result in failure. A channel usually remains underneath the sutured skin and the suppuration soon returns.

I shall cite only four cases, which will suffice for illustration, although the method has been applied in practically every form of chronic suppuration in the body, including tuberculosis of the spine and all other joints.

*Crushing injury of foot treated with bismuth paste.* E. P., a man of twenty-two, while riding a motorcycle, was run over by a motor truck. The right foot was crushed completely by the heavy wheel (see Fig. 5). The heel having been torn away, it was replaced and gauze drains introduced. On account of the virulent type of infection, condition grew worse, the fever rose to  $105^{\circ}$ , so that an amputation was contemplated. Gradual improvement, however, took place and a profuse chronic suppuration from six different sinuses resulted, persisting for two months.

Injection of bismuth paste was then resorted to, as shown in Fig. 6. Within three days the purulent discharge became serous in character. From then on the condition improved rapidly and the sinuses began to close. Within two months the limb was entirely healed and gradually assumed normal shape. Patient is now able to walk without the use of a crutch (Fig. 7 *a, b, c*).

*Infection of bone plates. Treatment with bismuth injections—subsequent skin flap operation.* A young man of twenty sustained a fracture of his left fibula. There was no abrasion on the skin. One week later a surgeon performed an operation, splinting the fragments with two steel plates. The day following the operation the young man developed a most extreme chorea, so severe that it required two men to hold him in bed. A week later I saw him in this condition. On removing a part of the cast, we found the entire area of incision in a semi-gangrenous condition, the sutures having cut through the tissues and pus oozing from all parts of the œdematous and inflamed limb (see Fig. 8).

The bone plates were removed and the infected wound was treated with bismuth paste injections for two weeks. No irrigation was employed. Subsequently the remaining cavity was curetted and a skin flap about two and a half inches wide and four inches long was denuded from the edge and shifted into the depth of the wound. Gauze was packed against it so as to keep it in place for healing. Adhesion of skin flap took place and growth of skin from the side of the flap progressed rapidly (as seen in Fig. 9, taken four days after the operation). The denuded surfaces of muscle and connective tissue were treated by the adhesive plaster method and skin gradually covered the entire denuded surface as seen in Figs. 10 and 11. The chorea gradually disappeared, the patient gained thirty pounds and is now able to walk without a cane.



FIG. 4.—The sinus opening, apparently from hip-joint disease, proves to be tuberculosis of sacrum, ascertained by means of bismuth injection.



FIG. 5.—Crushing injury of foot, infected and drained in six places; bones crushed.

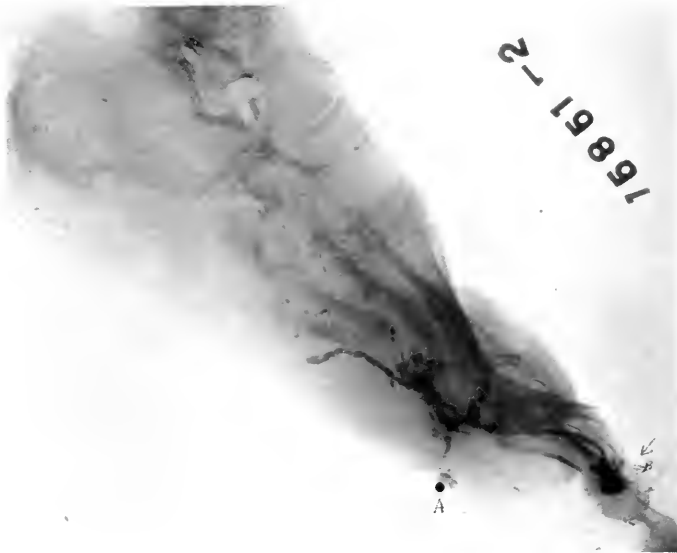


FIG. 6.—Radiogram of the foot after injection with bismuth paste.



FIG. 7a.—Sinuses closed after bismuth injections, but denuded surface still present.



FIG. 7b.—Perfect closure of all sinuses. Foot in extension.



FIG. 7c.—Foot in flexion.



FIG. 8.—Plated fracture of fibula, with secondary infection. Necrosis of skin and muscles.



FIG. 9.—Excision of necrosed bone, muscles and skin. Skin sliding operation.



FIG. 10.—Condition two weeks after operation by treatment of adhesive plaster for skin regeneration.

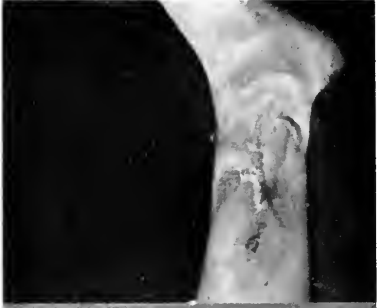


FIG. 11.—Complete closure four months after operation, with perfect function of leg.



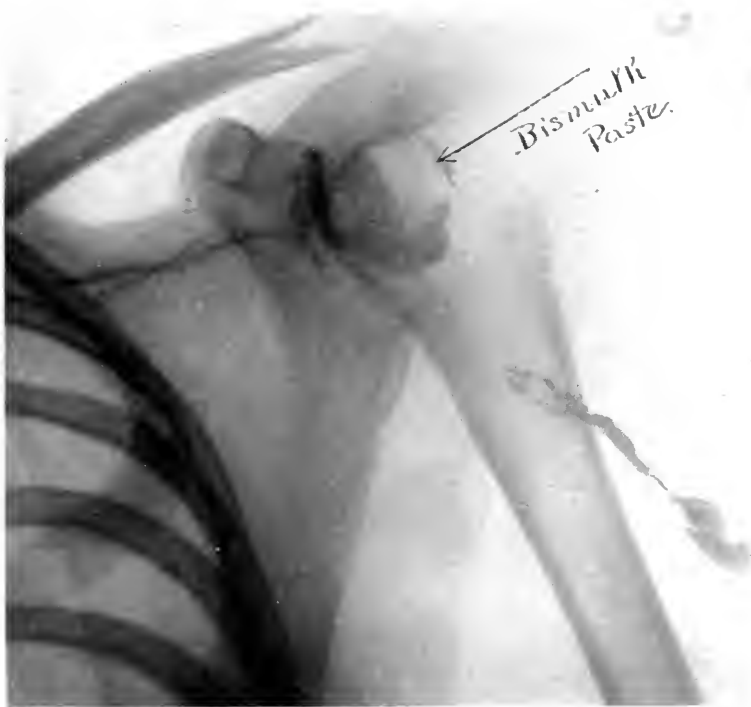


FIG. 12.—Tuberculosis of shoulder, injected with bismuth paste.



FIG. 13.—Extra-articular infection.

*Tuberculosis of scapula, including glenoid cavity.* Miss S. G., aged eighteen, developed tuberculosis of spine at the age of three; wore a corset for two years and a spontaneous cure followed. Ten years later she developed a swelling in the middle of her upper right arm on the left side. The condition was diagnosed as a dislocation of the shoulder, and under anæsthetic the physician tried to reduce it. Later it was found to be an abscess, which was incised and drained. Condition then was supposed to be an osteomyelitis of the humerus. The discharge of pus persisted until March, 1917 (three years), when I first saw her and injected the sinus with bismuth paste and found the following (Fig. 12):

The sinus leads into the glenoid cavity, the head of the humerus is eburnated, the glenoid cavity devoid of cartilage and the external border of the scapula shows the healed out tuberculosis.

The injection of the paste had the effect of promptly closing the sinus within two weeks. Same has not reopened, and motion of the shoulder has become almost perfect.

*Extra-articular abscess following injury, mistaken for tuberculous knee.* J. V., a boy eight years of age, received a slight injury to his knee by falling, in January, 1909. This was followed by lameness. The condition, however, did not become much aggravated until April, when a swelling and pain of the knee developed. The physicians in California diagnosed the condition as tuberculosis of the knee and advised resection. His home being in Chicago, he returned and again consulted surgeons, who also diagnosed the condition as tuberculosis of the knee with the same advice, "resection."

In this condition the patient entered the hospital in August, 1909. With the aid of a set of stereoröntgenograms of the knee, the diagnosis of tuberculosis became doubtful, only an extra-articular abscess without bone lesion was suspected.

Through a small incision I evacuated about two ounces of pus (staphylococcus). Injection of this abscess (Fig. 13) shows the extent and ramifications of the undermined extra-articular pus pockets. A stereoscopic picture proves beyond a doubt that no pus or paste entered the joint itself and the further progress of the case proved the correctness of our diagnosis. Within three days the sinus closed and within one week the boy had perfect motion and normal shape of his knee. A radiogram taken six weeks later shows the perfect joint, without the slightest destruction of any bony tissue.

Even with the correct application of the bismuth paste there will remain a certain number of cases uncured because of the inaccessibility of the injection to all diseased parts or of the retention of a foreign body. For such cases a most radical procedure is necessary, which I shall here describe.

*Skin Sliding Operation for Osteomyelitis.*—The principle employed is practically the same as that in the lung abscess cases.

The diseased area, being located by means of radiograms, is freely exposed by cutting away all the unhealthy skin and scar tissue. The diseased bone is then thoroughly curetted or chiselled away until one is certain that

there is not a vestige left. Should this produce a deep groove, the same must be converted into a very shallow one or even into a flat surface by cutting away a sufficient quantity of healthy bone on either side.

This being done, a skin-flap is cut from one or each side, sufficiently large to nearly cover the denuded bone surface, care being taken, however, that no subcutaneous fat is carried with it. The flaps are then shifted into the depth of the cavity and retained there by packing gauze against them. It is not absolutely necessary that every part of the bone cavity be covered. The skin will grow from the edges of the flaps until every portion of the raw bone surface is covered with true skin. To prevent retraction or slipping of the skin-flaps, I have frequently used a carpet tack to temporarily fasten the tip of the skin-flap to the bone until adhesion has taken place. The areas of muscle and subcutaneous tissue which have been exposed by sliding the skin are left denuded. No attempt should be made to bring their edges together by suture or otherwise. In only very rare instance has it been necessary to use any suture material whatever, except, of course, the ligation of bleeders.

When the wound is not too deep, the skin-flap may be omitted. It is simply left widely gaping and packed with gauze and allowed to granulate from the bottom. Later on adhesive plaster is put on the edges of the wound. This procedure has thus far been carried out in 34 cases; a variety of diseases including osteomyelitis and tuberculosis of joints, among which are two cases of spondylitis. There was no mortality. All cases have closed except those which have been operated upon too recently. These are progressing satisfactorily.

A detailed report of these cases will be given in a future publication.

#### SUMMARY

1. The methods of primary sterilization by means of flushings with hypertonic solutions should be thoroughly tested, to determine their effectiveness without the additional use of pastes.

2. The radical excision of infected tissues, as now practised in the war hospitals, should be adhered to, as a means of preventing chronic suppuration.

3. In those cases in which early sterilization was not obtainable and the wounds persist in suppurating, the bismuth paste injection or similar formulæ should be employed, before another radical operation is resorted to.

4. Correct technic in applying bismuth paste is essential if satisfactory results are to be obtained.

5. Bismuth paste and similar formulæ are applicable in chronic suppurations resulting from war wounds, as well as in those due to chronic infectious diseases.

6. In the residue of cases in which the bismuth paste treatment is not effective, the sutureless skin sliding operation<sup>9</sup> should be employed, since with this method we are able to clear up nearly all of these apparently hopeless cases.

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<sup>9</sup> E. G. Beck: Surgery, Gynecology and Obstetrics, March, 1918.

## INJURIES TO THE MALAR BONE AND ZYGOMA

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IN current descriptions of injuries to the face it is noticeable that attention is directed largely to fractures of the nasal bridge and mandible. In view of the very obvious disabilities produced by blows upon these regions this is not surprising, but there are other bone injuries generally dismissed after the briefest notice either because of their comparative rarity or from the fact that they do not force themselves upon the attention of the clinician by any serious consequences. As an example of the former group, fracture of the maxilla in industrial accidents may be cited. The object of this paper, however, is to call attention to effects of blows upon the cheek, blows which may produce quite extensive damage yet, owing to the defensive mechanism of the face, easily pass unrecognized.

Damage to the cheek results in local extravasation and in swelling, features which obscure the actual condition of the bones. Some temporary disability in the action of the masticatory muscles may result, but there is often no concussion as from a knock-out blow, and since actual permanent interference with normal functions is rare, there is as yet no adequate description of the lesions so far as I have been able to discover. The construction of this part of the face, which, because of its exposed position, is so liable to injury, lends itself to the absorption of shocks and the irradiation of blows, and from this point of view is most instructive. The effect of a blow upon the zygoma or outer border of the orbit is localized by the fragility of the bones and is not transmitted to regions further afield as in the case of the mandible: hence the relative immunity from concussion. In consequence of the facial architecture no permanent sequelæ are likely to develop, save a localized deformity of varying extent. Permanent interference with the mechanism of the temporomandibular joint, the action of the masticatory muscles or the suspension of the eyeball is rare.

In a survey of the literature it is apparent that estimates of lesion to the malar and its processes are computed by the only cases which come under clinical observation. These include widespread fractures in which the lesion to the malar is merely an incident and occasional cases in which damage to the malar or zygoma alone has resulted in marked disability. They do not include those extensive injuries which result in speedy death or the majority of cases of more local damage.

Murphy<sup>1</sup> and Rawling<sup>2</sup> refer to instances of very severe injury only. Speed<sup>3</sup> notes that only seventeen cases presented themselves at Cook County Hospital, Chicago, in eight years. Authors in general agree in stating that fractures localized to the malar bone and its immediate neighborhood are rare. Roberts and Kelly<sup>4</sup> hold that fracture of the malar body is more

common than fracture of the processes and that true suture dislocation seldom occurs. Stimson<sup>5</sup> observes that single fractures of the malar are rarer than multiple ones, and that the rarest form is simple separation at the sutures with some splintering; but he indicates the inadequacy of clinical statistics by his statement that only in one recorded case has displacement interfered seriously for any length of time with movement of the jaws, and even this case recovered without treatment.

It is with the view of correcting the impression gained from clinical observation alone that the present investigation is recorded. I shall not refer in the following description to those instances which from the severity of the injury terminate speedily in death, but shall include only the cases which are of clinical importance and those which, since they are not followed by sequelæ forcing themselves upon the attention of the patient, do not come under clinical observation.

In examining the cheek bones of a collection of skulls for lesions, many of which are not very obvious at first sight, there are two pitfalls which must be avoided. The first of these is variation in the shape of the zygomatic arch itself. In the great majority of European and negro skulls the zygomata are curved in symmetrical fashion to form arches convex laterally. Occasionally a skull is found in which the zygomata are not arched but form uncurved bridges across the temporal fossæ. A few skulls show asymmetrical zygomatic arches. In these variations from the usual architecture there is nothing to indicate violence: they are therefore eliminated from the present discussion. A condition not very infrequently found, resulting apparently from slight disharmony in growth, is a pseudoluxation of the suture between the orbital process of the malar and the great wing of the sphenoid. This is the second type of anomaly to which reference must at once be made. In such cases there appears an angular union of the bones at this suture or, more rarely, an overlapping of the sutural edges. When one thinks of all the correlation which is involved in orderly growth of the face it seems remarkable that this type of disharmony is relatively rare and little marked.

Setting aside the foregoing peculiarities it is now possible to proceed directly to the consideration of pathological results of blows upon the cheek.

In the museum of this laboratory are thirty-eight skulls showing definite lesions of the type under discussion. All are the skulls of Europeans or of American negroes. Any considerable collection naturally represents individuals of varied social grade. To gain a fair idea of the percentage of this injury it is essential to define the social scale of the population examined. In our collection the European and negro skulls are those of individuals of the lowest grade of social life in America, human derelicts such as ultimately find their way into the dissecting room. On the other hand, the skulls belonging to individuals of other races, so far as our collection goes, represent the population at large without discrimination. Since lesions of the character under discussion may be expected to occur much more com-

## INJURIES TO THE MALAR BONE AND ZYGOMA

monly in the lowest social grade, it would only vitiate our statistics and give a false impression of the frequency of the injury were we to include in the survey the skulls of individuals other than European or negro.

Confining our attention to the European and American negro collection,\* there have been examined 373 of the former and 94 of the latter. Among the 373 Europeans, 31 †, or 8.3 per cent., showed lesions of the cheek bones, and among the 94 colored there were 7, a percentage of 7.4. No doubt the difference in percentage is negligible and results from the much smaller proportion of colored skulls at hand. In the combined total of 467 individuals 38, or 8.1 per cent., had suffered pathological deformation resulting from blows upon the cheek.

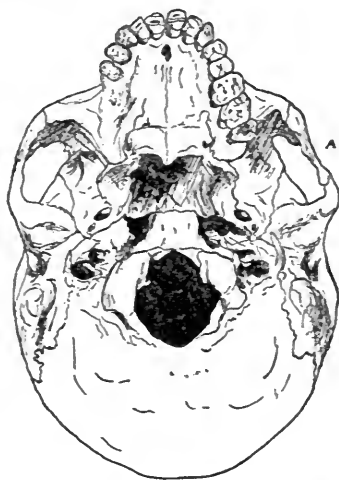


FIG. 1.—Base view of skull (465) of white male aged fifty, illustrating a very frequent type of damage to the zygoma producing no appreciable ill effects.

No particular light is thrown by this examination upon the age at which the injury occurred. All are old healed lesions.

Regarding sex it is worth noting that only two skulls are those of females (both European). From the nature of the injury it is plain that it will be rarely found in female skulls.

DESCRIPTION OF CASES.—*Zygomatic Series*.—Injury restricted to the zygomatic arch. Of this type there are two degrees, depression and fracture-dislocation.

Depression alone of the zygoma, usually most pronounced at the temporomalar suture (Fig. 1), occurs sixteen times, the injury being on the left side in ten cases and on the right in six. The two females (skulls 355 and 411) exhibiting injury both fall into this series.

The more severe form (Fig. 2) in which fracture of the arch or dislocation at the temporomalar suture occurs is found fourteen times, twelve

\* The following skulls have been examined: White, Nos. 0.1-0.130, 15-518. Colored, Nos. 0.47-0.131, 25-528.

† Skull 295 exhibits a lesion on both sides.

times on the left side and only twice on the right. The injury may or may not be accompanied by depression of the arch. Fracture may occur in the temporal part of the arch or in the malar part or in both, but the temporo-mandibular joint is never involved. When depression occurs it is less marked as a rule than in the foregoing type.

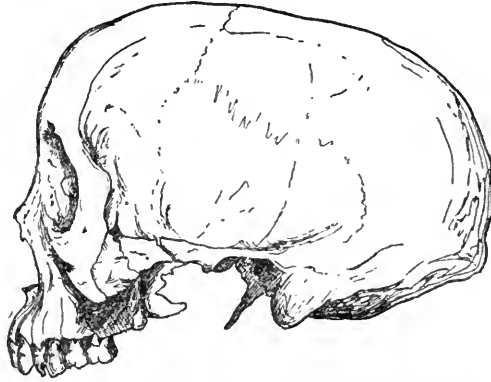


FIG. 2.—Skull (97) of colored male aged fifty, showing more severe injury to zygoma. Fracture of the arch has occurred in three places but is now healed with very little callus formation.

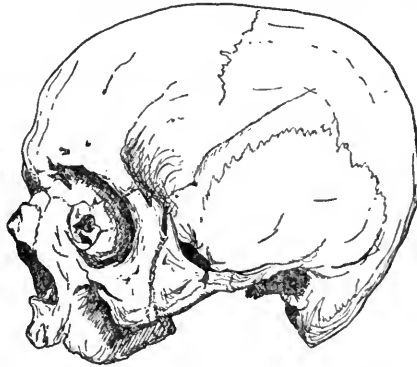


FIG. 3.—Skull (0.35) of senile white male, presenting an unusual type of injury to the zygoma. A rare congenital anomalous vertical separation of the malar into two has permitted bending at the anomalous suture in addition to the more typical fracture-dislocation of the zygoma proper.

An unusual example of the second class is illustrated by Fig. 3, in which a rare and anomalous vertical subdivision of the malar is present. Separation of the two portions of the bone has resulted from the force of the blow.‡

‡ Doctor Hrdlička has reported a case similar to this with some uncertainty as to whether it is a mere fracture or a genuine malar subdivision complicated by fracture. It is therefore important to note that there is a vertical suture on the mesial aspect of this malar bone almost coinciding with the line of fracture. The suture is not visible on the lateral aspect and it is unfortunately unilateral. Since this article was written another skull (No. 534, male, white, aged sixty-eight) has been added, which presents a similar lesion on the right side, but in this case there is no vertical suture to be seen. It is therefore probable that Dr. Hrdlička's interpretation that a line of fracture can occur here is correct and that the vertical suture seen in skull 0.35 bears no direct relation to the site of fracture. (See Hrdlička, *A. Am. Nat.*, 1902, vol. xxxvi, p. 292.)



FIG. 4

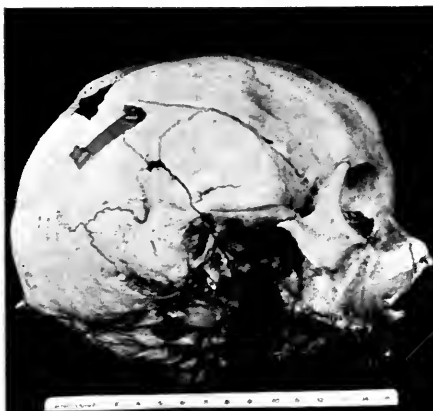


FIG. 5



FIG. 6



FIG. 7



FIG. 8

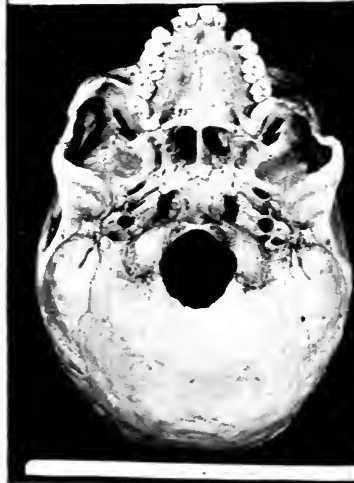


FIG. 9



- FIG. 4.—Skull of white male, showing rotation and depression of the malar bone and a wound of the vault. The braced fracture and the loss of bone in the parietal region are clearly visible.
- FIG. 5.—Skull of white male aged fifty, showing lowering of the orbital margin and buckling of the maxilla resulting from a blow directed upon the lower margin of the right orbit.
- FIG. 6.—Skull of white male aged forty, showing destruction of the entire floor of the right orbit consequent upon a blow on the malar.
- FIG. 7.—Skull of white male aged fifty, to show fracture of the right malar bone extending to the sphenomaxillary fissure.
- FIG. 8.—Skull of white male aged forty-one, showing the displacement backwards of the outer orbital margin resulting from a blow which has buckled the left maxilla.
- FIG. 9.—Skull of white male aged forty-five, to show dislocation of the temporal bone and buckling of the maxilla following a blow on the malar.



FIG. 10.—Skull of senile colored male, showing the forcing apart of the two portions of a bipartite malar bone in addition to fracture-displacement of the zygomatic arch. Note the osteophytes on the zygoma and on the attachment of the temporal muscle immediately adjacent to the anterior root of the zygoma.

*Malar Series.*—Injury centring on the malar bone. Examples illustrating this type may well receive a closer individual scrutiny because of the varied effects resulting therefrom. The blow results in crushing back of the malar, deformation of the orbit and buckling with fracture of the maxilla. Five times the lesion occurs on the right side, four times on the left.

As a first example of this series skull 0.117 (Fig. 4) is presented. It is that of a white male well beyond middle life and displaying a rather feminine cast of features, who has been struck by an edged instrument (probably a sword) upon the side of the head. There is a linear fracture, long healed, extending through the right parietal, the squamous temporal and great wing of the sphenoid. The right malar has been displaced and there is depression of the bone near the temporomalar suture. The frontomalar, malar-sphenoid, and malar-maxillary sutures are dislocated and the malar rotated about a vertical axis, the maxillary process being thus drawn away from the maxilla itself.

Skull 189 is that of a white male aged forty-three, and illustrates upon the left side a condition similar to that in the foregoing instance, except that the injury has been produced not by a sharp instrument but by a blow of the fist. There is the same depression and vertical rotation of the malar and dislocation at the same joints. But in this case the maxillary process of the malar, being very fragile, has been broken across instead of being wrenched off from the maxilla.

In skull 492 (Fig. 5), that of a white male aged about fifty, the blow has fallen directly upon the lower margin of the right orbit. The maxillary process of the malar is broken and depressed, causing lowering of the orbital margin. The facial aspect of the maxilla is buckled.

In the ensuing six skulls the blow has been delivered more directly upon the body of the malar.

Skull 429 (Fig. 6), belonging to a white male, aged forty, shows that considerable damage may occur with but slight facial evidence. A first glance indicates merely that upon the right side the frontomalar suture has been dislocated, the bones being pried apart quite considerably, and that there is some buckling of the facial aspect of the maxilla with depression of the inferior orbital margin. Further inspection reveals destruction of the entire orbital floor. The zygomatic process of the maxilla bearing the malar has been wrenched away from the rest of the bone, the facial and infratemporal surfaces being split and continuity maintained only below. There is but slight depression of the zygomatic process of the malar and rotation of the bone around its vertical axis.

In skull 116 (Fig. 7), that of a white male aged fifty, fractures occur in the zygomatic process of the squamous temporal and in the body and orbital process of the malar immediately above the zygomatic foramina. The latter fracture extends into the inferior orbital (sphenomaxillary fissure). In addition the frontomalar and malar-sphenoid sutures are dislocated. Around the root of the zygomatic process the facial and infratemporal surfaces of the maxilla are split and the base of the process driven into the maxillary antrum. No doubt the fractures of the bones prevented greater buckling such as is found in the next specimen.

Skull 295 (Fig. 8), belonging to a white male aged forty-one, has been included already in the zygomatic series since it displays upon the right side depression of the zygoma at the temporomalar suture, but must also be referred to in the malar series because it presents a marked deformity upon the left side. In this case a blow delivered directly upon the cheek has buckled in the temporal process of the malar as well as the zygomatic process of the maxilla, the latter damage being accompanied by some

destruction of the infratemporal and orbital surfaces of the upper jaw. In addition to these, there is fracture of the orbital process of the malar and dislocation of the frontomalar suture. The nasal bones also are fractured and displaced to the right, probably as a result of the same blow.

Skull 148 is that of a male white, aged fifty-five. Again the damage to the left cheek area is complicated by fracture of the nasal bridge with displacement to the right. There is dislocation at the temporomalar suture accompanied by some depression of the temporal process of the malar bone. The malar-sphenoid suture is dislocated. The entire maxilla has been comminuted, orbital, infratemporal and facial surfaces being involved, the last mentioned mesial to the infra-orbital foramen. The floor of the orbit is depressed.

Skull 419 (Fig. 9), from a white male aged forty-five, has suffered like but more extensive damage, although the dislocation at the temporomalar suture is not complicated by depression of the temporal process of the malar bone. The frontomalar suture has been loosened in this instance.

Skull 0.47 (Fig. 10), which also falls into this group, is at first sight difficult to interpret. It is that of a senile male American negro. Comparison of it with Fig. 11, which is an outlined sketch from skull 0.62 (colored, male, aged forty-five), gives the explanation. There has been upon the left side a bipartite malar bone the two portions of which have been separated by the blow. The forcing apart of these has been con-



FIG. 11.—Skull of colored male aged forty-five to show the bipartite malar bone. Compare this with Fig. 10.

tinued as a splitting of the maxilla. Other complications are also present. There is fracture of the greater wing of the sphenoid with dislocation of the malar-sphenoid suture and fracture of the zygomatic process of the temporal. Some local osteophytic growth occurs on the zygoma itself, on the anterior root of the zygomatic process of the temporal and on the coronoid process of the mandible. The upper fragment of the malar was wrenched by the blow almost entirely free from the rest of the facial skeleton, although later firm union occurred.

*Interpretation of the Foregoing Observations.*—Having stated the pathological results of blows upon the cheek as exemplified in the present study we may consider briefly certain general aspects of the injury. As already stated, lesions of this nature occur with greatest frequency in the lowest grade of society. There is a sharp distinction between the less extensive type of injury, that confined to the zygomatic arch alone, and the features resulting from a blow upon the body of the malar. Whereas among the former graded injuries occur, the latter are invariably severe. Nowhere in our museum are there to be found specimens showing only slight damage of

the malar series type. Apparently, therefore, the force of less heavy blows is effectively absorbed by the resilience of the facial skeleton and dispersion over the several buttresses converging upon the malar bone. It is obvious, however, that beyond a certain limit the buttresses give way or the maxillary base of the malar buckles. Thus the force of the blow is absorbed and further ill-effects minimized. "Spent" blows are not represented in the malar series.

From the damage described certain deductions can be drawn regarding the character of the blow. In the zygomatic series in general lesions occur most frequently upon the left side. In the less severe grade, where there is merely depression, we find ten instances of left-sided and six of right-sided injury. There is here a much higher percentage of injuries of the right face than in the other classes discussed below. Allowing for the non-scientific character of the fighting it would appear that these lesions are produced either in parry or in counter-blow, the face being turned to the side. The parry by the guard arm would greatly diminish the force of a direct blow and the counter-blow would rarely have the strength of a direct thrust. In both cases the recipient's side face is exposed. In the more severe grade of the zygomatic series, that in which the arch is fractured, the lesion is found much more frequently upon the left side (twelve times left, twice on right). This may reasonably be interpreted as the counter-blow of a stronger opponent delivered while his antagonist is at the stage of recover, although some of the injuries are probably from direct thrusts. In the malar series damage occurs with equal frequency on both sides (left four, right five) and since less forceful blows are not illustrated there are fewer instances than in the zygomatic series. Parried blows and counter-thrusts are not represented. In every case there has been a direct blow which the opponent has had no opportunity of resisting effectively: He has not even turned his face to receive the blow upon his zygoma.

We must now consider the effects of the damage details of which are at first obscured by swelling. Crushing in of the zygoma in either zygomatic or malar type may affect the movements of the temporal muscle. That such a result does follow is indicated by skull 0.47 (Fig. 10), in which osteophytic growths in the attachments of the temporal muscle and fascia are seen. There is no doubt that this sequela does not always occur. Dr. J. J. Thomas tells me that he has observed such depressions without any resulting interference in muscular movements. Dr. C. A. Hamann informs me that he has noted pain and difficulty in moving the muscle shortly after the injury, but since these cases do not continue to present themselves for treatment and, again, since of all our series 0.47 alone exhibits any osteophytic outgrowth either on skull or mandible, it may be presumed that these symptoms shortly subside. Only in one case (skull 358) did I find any arthritis of the temporomandibular joint. As arthritis of this joint is not very infrequent in our collection and skull 358 exhibits merely slight depression of the zygomatic arch, I am disinclined to consider it consequent upon the

damage to the facial skeleton. In no instance is there evidence of prolonged suppuration in the maxillary sinus. Regarding the infra-orbital nerve there is no evidence to point to injury. In every case in which the floor of the orbit is damaged (skulls 148, 295, 419, 429) at all extensively the injury passes either mesial to or through the infra-orbital groove and canal but without resulting constriction or wide separation of bone fragments.

Passing to the effect upon the orbit we note that this may be quite marked, yet whether this has influence upon the slinging of the eyeball between the attachments of the tarsal ligaments is another matter. Distortion of the orbit is necessarily a result of direct blows delivered with some violence upon the malar; it does not result from blows upon the zygoma. The lateral wall is frequently set back especially below and the lower margin is depressed. The latter deformity increases the vertical orbital height, but since this varies so greatly with the individual, with sex and with age, it is not conceivable that it can have any functional significance. Alterations in the transverse breadth of the orbit may be more important as such a deformity may affect the position and tension of the suspensory ligament which is attached to the lachrymal and malar bones.

Customary anthropological measurements of orbital breadth are made without reference to the suspension of the eyeball and are therefore useless in the present connection. In order to have a standard I took fifty European skulls (281-356) and measured with sliding calipers the distance between the dacryon and the malar tarsal tubercle.<sup>6</sup> The former point (junction of sutures between frontal, nasal process of maxilla, and lachrymal) afforded a fixed point close to the inner attachment of the suspensory ligament which itself is often difficult to identify on macerated skulls. The latter point was adopted because it indicates precisely the lateral attachment of the ligament. Of these fifty skulls the orbital breadth was the same on both sides in twenty-two; the right orbital breadth was the greater in fifteen; the left greater in thirteen. In only one case (skull 336) was the difference between the orbital breadths of the same skull more than one millimetre. In this skull there is general asymmetry.

Referring to the lesions noted in the present survey it is plain that only in the malar series may we expect to find any possible effect upon the position of the eyeball, and even here, as indicated by Murphy's case, the excursions of the eyeball are not likely to be altered in extent. The only effect short of blindness from a lesion of the optic nerve or macula or of bursting of the eyeball will be loss of stereoscopic vision. This is brought about by displacement of the axis of the eyeball in consequence of change in relative position of the malar tarsal tubercle. Of the nine cases in this series displacement of the tubercle in the three dimensions of space can be tabulated in the following manner:

Displacement in the transverse horizontal axis is suggested in four. For the sake of simplicity the orbital breadth on the sound side may be taken as the normal for each skull.

## INJURIES TO THE MALAR BONE AND ZYGOMA

Skull No.	Displacement of malar tubercle
0.117 .....	4.0 mm. laterally.
189 .....	1.5 mm. medially.
295 .....	1.5 mm. laterally.
419 .....	1.0 mm. laterally.

In the first of the foregoing instances there is no doubt that displacement occurs: in the others displacement may be doubted in view of the normal variation in orbital breadth on the two sides, a variation which does not exceed 1 mm. The suggested displacement is, however, important in association with the figures in the following lists:

Displacement in the vertical direction can be gauged by separation of the fragments in fracture-dislocation of the frontomalar suture, a lesion which in the present survey occurs much more frequently at the suture than in the bone adjacent. The extent of the gap indicates the displacement of the tubercle. It occurs in four skulls.

Skull No.	Vertical displacement of malar tubercle
0.117 .....	1.5 mm. downward.
295 .....	2.0 mm. downward.
419 .....	1.5 mm. downward.
429 .....	2.0 mm. downward.

Displacement of the tubercle backwards will obviously be the most extensive and accompanies the crushing back of the malar. It is suggested in seven of the skulls. This measurement was taken by placing one limb of the sliding calipers in the external auditory meatus so that it rested upon the anterior margin at the junction of tympanic and squamous temporal portions; the other limb was then adjusted to the orbital margin at its nearest point to the meatus. The difference between the readings on the two sides gives approximately the displacement of the malar tubercle. In order to check off this against the normal fifty European skulls (281-360) were measured in the same manner. In normal skulls the measurement was either the same on both sides or varied not more than 0.5 mm. to the right or left unless general asymmetry occurred in face or entire skull on the one hand or marked loss of teeth on the other. The point upon the orbital margin nearest to the external auditory meatus is so close to the malar tubercle that this convenient measurement was substituted for the more difficult direct estimate. The figures given by the normal skulls indicate that we may ignore the displacement in skull number 189 only, though even then the difference in this measurement is probably to be associated with the difference noted in the first list.

Skull No.	Displacement of malar tubercle backward
0.47 .....	2.0 millimetres.
0.117 .....	1.0 millimetre.
148 .....	5.0 millimetres.
189 .....	0.5 millimetre.
295 .....	2.0 millimetres.
419 .....	1.0 millimetre.
429 .....	3.0 millimetres.

It will be noted from the foregoing statistics that the most constant permanent result of damage to the malar bone is alteration of the axis of the eyeball. Whether this is followed by interference with stereoscopic vision, at any rate in the cases of less pronounced axial alteration, would be a matter for clinical observation. In examining normal cases I find that there is a distinct difference between the distance of the orbital border from the external auditory meatus in those individuals who have lost a considerable number of teeth on one or both sides, whereas this does not obtain in skulls still retaining a practically full dentition. So far as I am aware, no observations have been made upon the relation of vision to this change in facial form. Even if interference with stereoscopic vision does occur with moderate injury to the malar bone it is not a result which will readily cause the patient to seek treatment. In any case there is no limitation of the excursions of the eyeball.

Defects of vision, whether purely temporary as met with in such cases at the present time in France and as recorded in McCurdy's case,<sup>7</sup> or permanent from lesion of the optic nerve, hemorrhage into the macula, and sluggish pupillary reaction,<sup>8</sup> like formication or anæsthesia in the area supplied by the infra-orbital nerve, and hemorrhage or inflammation in the maxillary sinus, the present material does not permit us to discuss.

Lastly, more or less temporary interference with the action of the masseter is not confined to the malar series, but is even more characteristic of the zygomatic group. No permanent disability is likely to result, and in none of my cases are there osteophytic deposits in the masseteric attachments.

#### SUMMARY

In summing up the foregoing observations one may state that contrary to the usual impression fracture or fracture-dislocation of the malar bone occurs alone or with extension only to the maxilla more frequently than as part of a widespread lesion; and that damage to the zygomatic arch is much more common than injury to the malar itself. The failure so far to appreciate these facts is quite natural, for the great majority of cases never come under clinical observation since they are accompanied by no permanent disability causing the patient marked inconvenience. The most frequent permanent derangement appears to be deviation of the axis of the corresponding eyeball. Interference with the action of masticatory muscles is usually temporary and affection of the infra-orbital nerve results in no pronounced symptoms.

Involvement of the temporomandibular joint, permanent blindness and other grave complications result from a much more severe injury. Cases exhibiting such serious disabilities form by far the greater number of those presenting themselves for treatment. Instances of less severe damage do not usually appear upon clinical records.



## INJURIES TO THE MALAR BONE AND ZYGOMA

Finally, we note that the very fragility of the facial skeleton in this region and its normal resilience form a natural protection against marked untoward effects.

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## KINEPLASTIC AMPUTATIONS

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THE utilization of mutilated members is not merely a surgery of sentiment but of high social duty. When a proper mechanism can partially replace the function of the lost member, the community will not completely lose the efficiency of the individual.

In the technic of amputations there has been in the last few years no other progress than that directed to the securing of a good weight-bearing power of the stump. The large number of amputations during the present war has attracted the attention of the surgeons to those methods which can be better adopted for the future application of a useful prosthesis capable of relieving a crippled condition. It has been for this reason that the *kineplastic amputation*, originated by Vanghetti, has been newly brought into light by the work of some Italian and German surgeons. It is not my intention to discuss the reasons why a method of such social value has been so little appreciated and applied. Very probably the conservative tendency of modern surgery and the great limitation of the amputations prevented a wide practical test of the Vanghetti experimentations. Besides, the necessity of having the coöperation of a mechanician to construct and fit a rather expensive apparatus, and the importance of a long and proper training of the patient, did not favor in peace times the spreading of a surgical method for which special institutions would have to be created.

In performing an amputation, the surgeon takes advantage of the soft tissues to cover and protect the bones. The muscles which have been cut through, being deprived of their distal insertions and having lost their functions, subsequently undergo a more or less extensive atrophy. In 1896 Vanghetti, by ingenious experiments on animals, tried to demonstrate that if the muscles of an amputated member are properly covered with skin and protected from retraction they can preserve their function of voluntary contraction and may be used to transmit motions to some mechanical apparatus. The muscles or tendons which, properly prepared by a surgical operation, become apt to animate a prosthesis, are called by him *plastic motors*.

The varieties and types of motors that can be obtained in an amputation stump depend on the place where the amputation takes place and on the special condition of the diseased part. Vanghetti, in a series of papers, has widely developed the theories of the motors and has described a great number

of them. For practical purposes they can be classified into two fundamental types, so far as their form is concerned: the *loop* and the *knob*.

The *loop* is made by the natural or artificial union of muscles and tendons, forming a space through which a ring can be adapted to transmit contraction outside.

The *knob* is an enlargement of the tendons or muscle-endings formed by the surgeon, either by twisting and suturing together a number of tendons, or by using a bone eminence where the tendon is attached.

Both loop and knob should be completely covered with skin. The knob will result in an enlarged part, the *head*, and a thin part, the *neck*, to be used to transmit the movements by applying a belt.

In regard to the way in which the function is performed, they have been classified as:

1. Motors that can execute movements only in one direction (simple motors or unimotors). A various number may be formed on the same stump so as to give different movements to the artificial limb.

2. Alternating motors or bimotors. These are capable of movements in two opposite directions. They are formed by suturing the antagonistic muscles on the section of the bone or on the articular surface (Fig. 10).

The kineplastic method can be adopted in every case of amputation, especially in those of the upper limbs (primary kineplastic amputation), by forming loops or knobs at the end of the stump. In other cases, by the careful suturing of the muscles over the section of the bones, the stump can be so prepared that the function of the muscles is preserved for a long time and a secondary kineplastic may be performed with a rather easy operation. This process has been called by Vanghetti *transitory kineplastic amputation*. Nearly ten years ago, almost at the same time, the Russian surgeon, Von Wreden, and the Italian De Francesco succeeded in forming plastic motors on old stumps which were the result of operations performed according to the old methods. As it would be rather difficult to formulate theoretical rules for kineplastic amputations, I will rapidly review the literature, and give an outlook on the technic followed by the surgeons who have practically applied the method.

#### CASES OF PRIMARY KINEPLASTIC

CECI (Pisa): It was Prof. Ceci of Pisa who first practically applied the theoretical and experimental work of Vanghetti. In the Surgical Clinic of the Royal University of Pisa, the first kineplastic operation was performed in 1900 and the case reported at the Italian Congress of Surgery (1905).

CASE I.—This case was a myxosarcoma of the radius with metastasis. The ampu-

tation was performed at the lower third of the arm with a loop between the biceps and triceps. Ceci made a circular flap of skin and subcutaneous tissue, one inch below the elbow-joint, which was dissected and turned up on the lower third of the arm. The bone was sawed, after carefully detaching the tendon of the biceps, whose ending was sutured to the triceps tendon forming a loop. Three centimetres above the margin of the skin flap, two lateral incisions of nearly five centimetres in the axial direction were made, so as to correspond to the middle of the tendinous loop. By suturing the edges of one incision to the corresponding edge of the other, a button-hole in the centre of the loop was the result (Fig. 1). The circular flap was sutured in an anteroposterior direction. As soon as the scar was solid enough, traction exercises were started through the ring, formed by the skin and underlying tendons, and in a short time the patient could easily raise four pounds. The loop was afterward provided with a ring and the contractions were transmitted to an artificial hand made by Redini of Pisa (Fig. 3).

CASE II.—Recurrent tuberculosis of metacarpophalangeal joints (1912). Amputation at the inferior third of the forearm. Tendinous loop between the extensor and flexor tendons. He dissected upward two rectangular musculocutaneous flaps, with superior basis. The endings of the tendons were sutured together as a stirrup. The skin of each flap was sutured so as to cover the loop. This case was a failure on account of necrosis of the skin.

CASE III.—Amputation of the inferior third of the forearm, for recurrent tubercular condition of the wrist-joint. In this case he attempted to form two independent motors. One was formed with the group of flexor muscles and the other with the group of extensors. The motor formed by the flexor tendons was used to give to the artificial hand the palmar flexion, while the extensor tendons were used to abduct the thumb. It is interesting to note the technic used in this case to cover the tendinous loop with the skin. On each cutaneous flap he made two longitudinal incisions at different heights and at such a distance that by turning the flap on itself, with the subcutaneous tissue inside, the incisions would correspond with each other to form a button-hole in the centre of the tendinous loop (Fig. 2, schematic reproduction).

ALESSANDRI (Rome): In 1906 Alessandri performed an amputation at the inferior third of the forearm with the plan to obtain two motors, one with flexors and one with the extensor tendons. He sutured together, at one end (dorsal), the extensor ulnaris with the radialis and a portion of the common extensor. On the other side (palmar) he stitched together the long supinator and internal palmar, with the flexor carpi ulnaris. Both loops were covered with the long quadrangular skin flaps which were sutured together all along the edges. A button-hole was cut in the middle of each loop, and sutures inserted along the margins. The operation was not successful on account of necrosis of the tendons and skin. The author warns against too complicated operations, and proposes performing the button-hole in a second stage when the vitality of the flap is insured.

SLAWINSKI (Warsaw, 1912): Kineplastic amputation of the forearm in a case of recurrent tuberculosis of the carpal bones. Circular incision a little above the radio-carpal joint and two lateral incisions of nearly eight centimetres on each side of the forearm. The circular incision exposed the bones so that the saw could easily be

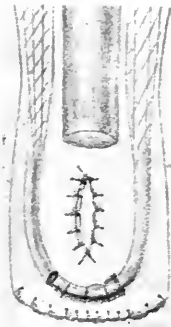


FIG. 1.—Schematic reproduction of Ceci's first operation.

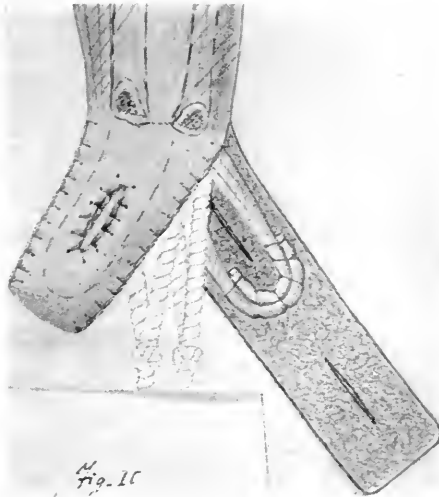


FIG. 2.—Schematic reproduction of Ceci's third operation: Anterior loop covered with skin; posteriorly shows tendon loop not yet covered with skin flap; tension strings applied. Same plan followed by Alessandri.



FIG. 3.—Ceci's first case with artificial hand. Note string through the loop (formed according to scheme in Fig. 1) animating fingers.



FIG. 4.—De Francesco's first case. Artificial hand voluntarily moved by a padded ring passed around the "neck of the knob." No other attachment.



FIG. 5.—Putti's second case—double knob (flexor, extensor). Belt to move pulley of the prosthesis.



FIG. 6.—Codivilla's kineplastic exarticulation of the foot. Posterior knob formed with the calcaneus, anterior with the extensor tendons.



FIG. 7.—Shows movement of the prosthesis attached to an ergograph.

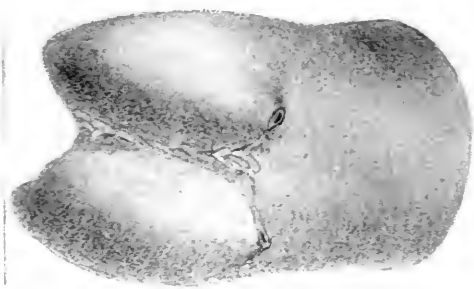


FIG. 8.—A double motor—one at extensor, one at flexor side (Sauerbruch).



FIG. 9.—Single motor on the flexor side—tube passed inside, with strings for exercises of traction) (Sauerbruch).

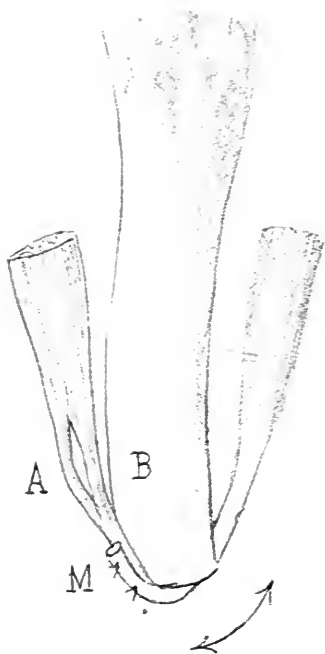


FIG. 10.—Reproduction of a bimotor (alternating motor). Schematic, from Pellegrini. *B*, bone; *M*, motor; *A*, attachment.



FIG. 11.—Suggestion of Pellegrini. A mobilized piece of bone used as an attachment of muscular loop in forming a bimotor.

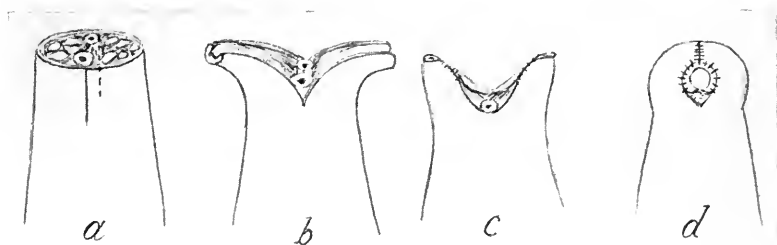


FIG. 12.—Pieri's suggestion for a primary kineplastic amputation. *a*, surgical preparation so as to have a Celsus stump—two-side incision; *b*, two flaps formed—bones sawed; *c*, sutures of flap to form two knobs; *d*, a motor loop is formed.



FIG. 13.—Muscular loop. Shows how to form a tube of skin for the exterior attachment (Sauerbruch).

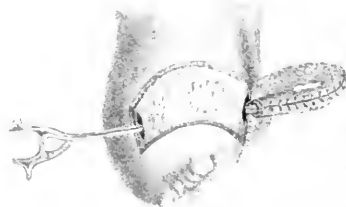


FIG. 14.—Cutaneous tube passed in a tunnel made in the motor (Sauerbruch).



FIG. 15.—Further step in forming the exterior attachment (Sauerbruch).

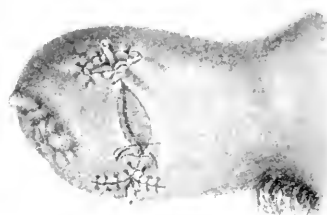


FIG. 16.—Repair of the skin. Rubber tube passed in the tunnel (Sauerbruch).



applied after retraction of the flaps. Of the two lateral incisions, the superior half was carried to the bones and nearly three centimetres resected. Muscle-tissue was interposed at the site of the resection. The stump resulted, divided by the resected bones, in two unequal portions. The small distal portion (knob), which was left attached to the muscles, could execute movements of flexion and extension on the central bones.

A. ZOPPI (Venice, 1915): Amputation at the lower third of the arm leaving a piece of olecranon attached to the tendon of the triceps to form a knob. An anterior loop was formed by the tendon of the biceps. Good function resulted.

PIERI (1917): His operations, recently published, are important for the fact that they were performed in a field hospital, soon after the injury. In three cases a shell had almost destroyed the hand up to the wrist. The section of the bones was completed a little above the radiocarpal joint. In the first of the series, a loop between the extensor and flexors was obtained and, by taking advantage of three cutaneous flaps, which were the result of the removal of the contused tissue, he succeeded in covering the loop. Although a necrosis of the skin and tendons destroyed partially the loop, he successfully utilized the stump for transmitting movements. This has been the simplest and most successful operation performed by Pieri. In the other two cases in which he applied a more complicated plan, trying to obtain three motors, the result was unsatisfactory as a primary result.

#### SECONDARY KINEPLASTIC OPERATION

The first operation to utilize old stumps, in which the muscles were capable of some contraction, was performed by Von Wreden, of Petrograd, in 1907. Man, of twenty-two years, who had already been amputated at the wrist. "The tendons of the forearm were strongly adherent to the terminal scar. They were put under tension by voluntary contractions of the muscles." This condition indicated to the author the possibility of applying the Vanghetti idea. He decided to use only the superficial and deep flexor, and performed under cocaine the following operation: "A small incision of an inch and a quarter in the direction of the tendons was made on the anterior side of the wrist. The tendons of the flexors sublimis and profundus were freely exposed. The superficial flexors were cut through at the level of their adhesion to the scar. These tendons were turned upon themselves and sutured on those of the flexor profundus. A loop was so formed between the tendons of the two muscles and the wound was closed with a few stitches. The loop which was outside of the wound was covered with two pedunculated skin flaps taken from the vicinity. The pedicles were cut two weeks after and the scar around the tendinous loop was so solid that one could start to give movements to muscles. The exercises were performed with a string passed through the loop. Little by little the patient was able to raise twelve pounds. An artificial hand was constructed according to Dalisch. The movements were transmitted through a nickel hook which fitted in the tendinous loop.

DE FRANCESCO (Giussano): Almost at the same time, in January, 1907, De Francesco made a movable knob on a man whose forearm had been amputated five years before at the inferior third. Two longitudinal incisions were made on each side of the stump, a little above the terminal scar, exposing the radius and ulna. A piece of each bone was resected about one inch long, one inch above the lower end. Both lateral

incisions were sutured. A traction was applied around the distal part of the stump by means of a special apparatus. After the wound healed a rubber padded ring was applied at the place of the resected bone. From this ring, cords transmitted motion to the artificial hand. Voluntary flexion of the fingers was obtained by tractions on the cords, relaxation could loosen the finger grip. After a while De Francesco noticed that the tension of the muscles had the tendency to approximate the free bony fragments and thereby lessen the space for the traction ring. To prevent this inconvenience and the fusing together of the two sections of bones, he removed completely one of the distal bones and put the other in a transverse position. Even in such a position the muscular retraction was so powerful as to make the space left by the resected bones almost disappear. Nevertheless, the patient could, with exercises, obtain an elongation of the neck of the knob around which the padded rubber ring could fit and transmit motions. The artificial hand was made by Marelli, of Milan (Fig. 4).

CASE II (1908).—Amputation of the middle of the forearm by the circular method. A year after De Francesco tried to form a knob by the same method described above. But in this case he resected an inch and a half of the terminal part of the bones and transversely implanted one of them in the terminal part of the wound, expecting that the neck of the knob could easier be fitted with a ring. A wire was passed through the central canal of the transversely transplanted bone, to make traction. The transplanted bone was extruded shortly after the operation and the author, taking advantage of the terminal soft tissues, which after the loss of the bone preserved good movements, perforated them. After the healing, he adapted in the holes special ivory buttons, through which traction cords were adapted. Patient could easily make movements and raise a weight of 2 kilogrammes.

CASE III.—Woman whose arm had been almost severed by a machine. After the crushed limb was removed, the humerus was sawed a little above the condyle. The tendons of the biceps and triceps, which had previously been cut through at their insertion (a piece of the olecranon was left attached to the tendon), were sutured together and covered with skin. Although the final result was very satisfactory, the patient refused to use the artificial hand.

PUTTI (Bologna): Soldier amputated at the inferior third of the arm. Kineplastic on October 15, 1915. Lateral incisions on both sides of the stump going over its terminal side. The incision is carried out so as to penetrate between the muscles of the anterior and posterior layer. The distal part of the humerus was resected to the extent of one-half inch, but it was left attached to the insertions of the anterior muscles. This piece of bone was buried in the muscular substance and covered with skin by suturing the edges of the longitudinal incision forming the anterior flap. With the posterior flap a knob was obtained by simply suturing together the longitudinal incision. Excellent result. Putti started the traction by using strips of adhesive plaster (adhesol) which were connected to a traction apparatus (Fig. 5).

SAUERBRUCH: During the present war Sauerbruch, Professor of Surgery in Zürich, has given the most extensive and practical application of the Vanghetti method. Although he claims that he started this kind of work at the suggestion of a mechanical engineer, Prof. Stodola, without knowledge of the previous work of other surgeons, it is really the kineplastic method, as originated by Vanghetti twenty years before, that he applied. Nevertheless, the technic of Sauerbruch, as it has

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been worked out in a great number of cases, has many original points that are worth remembering. In his first report of five cases, he described three types of operation. In the first type he forms, with the flexor and extensor muscles, two cutaneous muscular flaps. After a convenient shortening of the bone, by suturing each flap over itself so as to form two pads (*Kraftwülste*), they will appear as divided by a small and superficial gap covered by skin. By refreshing, in the second operation, the margins of the gap and by suturing the opposite surface, one obtains a cutaneous canal through which a stick can be passed to transmit motions. This method was used for the high amputation of the arm, the force of the muscles being capable of giving movement to the forearm and hand. In the second type, by adopting the same system, he took advantage, in the same way, either of the extensor or of the flexor muscles. In these two types it was necessary to remove the bone a little higher. In the third type to prevent such inconvenience, he covered the end of the stump with a flap of skin taken from the chest. Afterward the muscular flap was transformed into a muscular ring as in types 1 and 2. In forming a single motor, he always used the flexor muscles as being more capable of strength. In the great majority of cases he adopted only one motor. Only in very special cases did he use more than one.

### KINEPLASTIC OPERATIONS ON THE INFERIOR LIMB

Although amputations on the inferior limb are to-day performed in a greater number than amputations of the arm, they have attracted less attention of the surgeons, so far as the kineplastic operation is concerned. In fact, the surgeons feel satisfied when they have given to the patient a good stump which can bear the weight of the body and allow the use of an artificial leg. In amputations of the leg, on account of the special disposition of the muscles, the making of kineplastic motors is easier, but more skill is required so as to not interfere with the weight-bearing power of the stump, which is the most essential thing for the patient. Very recently, another German surgeon, Blenke, without apparently any knowledge of the rather old literature, has warmly recommended the kineplastic method.

CODIVILLA (Bologna) was the first to apply, in 1910, the Vanghetti principles on a case of amputation of the foot for tuberculosis of the tarsus. The case seems to me of such importance that I wish to refer to it extensively. "The methods," he wrote, "that had been applied in the amputation of the arm were not available. The stump ought to be so fitted as to support the weight power and at the same time transmit movements to the artificial foot. The most essential thing was to have a considerable degree of plantar flexion in such a way that the motors could have a rather wide excursion. The operation was performed as follows: A wide flap (skin, fascia, and plantar muscles) was designed and dissected to cover the stump. The basis of it was at the inner side, because the skin on the outer side was not healthy. Then two other flaps were dissected, one anteriorly with its basis on the ankle-joint and reaching way down, as far as the condition of the

skin allowed, another posteriorly with superior basis, and with an outside direction. The foot was disarticulated at the ankle-joint, and a piece of the os calcis was left attached to the gastrocnemius tendon. Only the malleoli were removed to give a flat shape to the articular surface of the joint. The tendons of the anterior muscles were sutured together and included in the skin of the anterior flap to form a knob, while the posterior external flap was used to cover the gastrocnemius tendon and the attached bone. The internal inferior flap was used to protect the extremity of the bones. The tension of the anterior and posterior muscles was obtained by passing silk strings through the basis of the flaps. These tension threads were removed after eight days. The result was the formation of an anterior and posterior motor controlled by the will. By their contraction, even the terminal cuff could slide on the bones. An artificial foot was constructed which could execute movements on the transverse axis. A concave and well padded plate of celluloid supported the terminal part of the stump. A leather belt passed around the motors transmitted flexion and extension movements" (Figs. 6 and 7).

GALEAZZI (Milan): Case referred at the Italian Congress of Orthopædics of 1911. In a case of disarticulation of the foot, he followed the same plan of Codivilla, but in his case, the excursion of the motors proved to be not wide enough to allow ample movements. The knobs did not acquire an independent power of mobility, and the anterior one did not result big enough to give a good hold to the pulleys.

PUTTI (Bologna) formed a kineplastic cuff, with the following procedure, in a case of amputation for sarcoma of the tibia. Anterior and posterior flap, as for a typical disarticulation of the knee-joint. With the anterior flap, beside skin, patella and patellar ligament, he dissected a great part of the articular capsule. With the posterior flap he dissected the flexor tendons and a great part of the posterior capsule. Posterior tendons and patella tendon were stitched together. A traction string catching the inferior margin of the patella was brought out and fastened to the dressing. A month after, active mobility of the patella was evident. The weight-bearing power was excellent.

Another kineplastic cuff on the knee-joint was made by Dalla Vedova of Rome, in 1913, but the patient died after the operation from tubercular condition of the lungs.

PIERI (1917), with the idea of imparting movements of plantar flexion to the artificial foot, made an attempt to utilize the calf-muscles to build a motor in a case of amputation at the inferior third of the leg. At the time of publishing his paper, the case was too recent to allow conclusions to be drawn or to speak of functional results.

The few successful cases from the old literature and the rather large experience of Sauerbruch who, up to the time of his last paper, had applied the method in over fifty cases, show that all the theoretical objections made to the Vanghetti theories are groundless. The problem of the prothesis, moved voluntarily by the action of the muscles which are the physiological remnants of the amputated member, is no more a theory but a real fact.

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The rather high number of unsuccessful cases must not be attributed to the method but to the fact that for so many years it has remained in the stage of experiment, and that no surgeon had the opportunity of having a great number of cases. The experience of the surgeons shows also that the difficulty in performing kineplastic operations is not in the forming of the loops or of the knobs, but in covering these parts with skin, especially at the site which must be used to transmit the contractions. The possibility of ulcerations, which are the cause of long and tedious healing, can be prevented only by the use of healthy skin which should be taken if necessary from another part of the body.

The fundamental form of motor called *knob* deserves special attention. It may be obtained with a rather simple operation at any level of an amputation stump. The places which give more facilities are those rich with tendons, as the tendons and the bone-eminences where they are attached offer an excellent material to form a knob; but the part used to transmit the motion to the prothesis (neck of the knob) does not give the same good hold as a loop. The first to apply this form of motor was De Francesco, who performed the operation above described. The inconvenience that he experienced in his cases was that the muscular retraction pulled the knob on the central bone, reducing the space where he had applied the padded ring. This can be prevented by the interposition of soft tissues between the bones. In such a way the operation becomes identical to the one made by Slawinski and can be used in all cases of long stumps of the arm and forearms. While in the transmission of the movements, according to operations of De Francesco, one utilizes the contraction of the muscles only in one sense, by attaching the prothesis to the head of the knob, one may obtain, by the antagonistic action of the extensor and flexor, a double motion. The action of such a movable stump becomes like that of a "double phalanx" (Vanghetti's expression) or like that of an "artificial carpus" (Pellegrini's expression) on which the artificial hand may be applied. In such a case Pellegrini proposes to adopt the same prothesis used by Delitala in the partial amputation of the hand in which the movement of the residual carpic bones are transmitted to the artificial fingers. Putti, in one of his cases, has shown how to form a double knob in a case of an old amputation of the arm.

### INDICATIONS AND TECHNIC

Although an outline of the technic has already been given by reporting rather extensively several cases, I think that at the present it will be useful to clearly formulate a few principles for kineplastic operations.

*The kineplastic method should be applied in any case of amputation provided that there are no contraindications either in the age or in the general condition of the patient. Such a rule is more strict in the amputation of the upper limb. Even if the surgeon for special circumstances is not in position to form plastic motor, he should look for the possibility of a future kineplastic, by adopting the principles of the *transitory operations*, so as to preserve the power of the muscles of the stump. It is necessary, from the clinical standpoint, to make a distinction between the traumatic and the non-traumatic cases, especially in regard to their possible application to war-wounds. In non-traumatic cases any method of forming plastic motors may be used, while in traumatic cases one should adopt the method to the special conditions caused by the injury.*

Here are a few general rules which should be remembered:

1. The adopting of a very simple operative method in order to obtain *one or two* motors.
2. The saving, in dissecting a flap, of as much skin as possible but not sacrificing too much bone; whenever it is deemed necessary, a pedunculated flap of skin can be taken from another part of the body in preference to the shortening of the amputation stump.
3. The muscles must be so managed as to save their innervation and vessel supply for the obvious reason of preventing atrophy.

*The applying of one method or another depends chiefly on the location of the amputation.* In a region rich in tendons, tendon-loops should be the choice; knob may be used also by taking advantage of the tendons and their bone-insertion. Where there are no tendons the muscles offer an excellent material. By suturing a muscle or an entire muscular layer over itself at one or both sides of the member, one may obtain a "*muscular knob*" or a "*muscular pad*" (Sauerbruch). Several muscles should be selected and sutured together to form a motor, instead of using a single muscle or a single tendon.

In traumatic cases an attempt to obtain plastic motors should be made only when the surgeon is sure of the sterile condition of the operative field. Whenever such a condition is doubtful it is better to renounce any idea of primary kineplastic and prepare the part for a later operation. In such a preliminary operation, especially in shell wounds, one must be very economical in removing contused or damaged tissues. In an injury at the wrist-joint special attention must be directed to save every little piece of tissue that shows even a trace of vitality, as it will be found useful in future kineplastic. In cases where tendons have been exposed it is wise to leave them without

resecting, because if they are cut the muscles will undergo a further retraction, while if they are left untouched and allowed to be eliminated by a slow process of necrosis they will form strong adhesions to the terminal scar and be valuable material for "future secondary" operations.

The only experiences with primary kineplastic soon after a shell-wound, so far as I know at this time, are those of Pieri. Although, as above referred, his results have not been encouraging, I shall report the outline he gives for a primary kineplastic amputation. "In case that the injury has severed the hand at the wrist, the wound should be rectified, by removing the contused tissues, so as to give to the stump the appearance of a Celsus amputation (Fig. 12a). The plastic motors can now be obtained as follows: Two lateral incisions about six to eight centimetres at the ulnar and radial sides of the stump are carried to the bones, and an anterior and posterior flap is dissected. Then the bones are resected for about five centimetres (Fig. 12b). To obtain a couple of knobs, the edges of each skin incision will be sutured in each flap in a longitudinal direction (Fig. 12c). Such a method may be applied also in the amputation of the arm (Putti). To obtain a loop (Fig. 12d) the skin is sutured with the same principle, but the ends of the tendons are sutured together so as to form a stirrup over the section of the bones."

*Transitory Kineplastic Amputations.*—Such a title Vanghetti and his followers apply to those operations which are so performed as to allow an easy kineplastic operation in a second stage. These operations do not essentially differ from the common amputations, but they are so modified as to give the possibility of forming the attachment apt to transmit movement to the prothesis. The muscles of the opposite side of the limb are sutured over the section of the bones, or over the articular surface in order to keep the muscles from retraction (Fig. 10, schematic reproduction). The forming of an attachment or of a knob may be made at any time, even after many years. To facilitate the fixation of the tendons or muscles over the stump the natural grooves or the articular surfaces must be respected, or made deeper, or transformed to a tunnel by opposition of the bones. If the muscles are not long enough to be fixed over the stump one may excavate a tunnel through which they may be united. Pellegrini, in a recent paper, has outlined various schemes which show how to utilize or how to use a mobilized piece of bone as a pivot (Fig. 11). Even one single bone may be used to attach the muscles when the other bone must be made shorter on account of pathological conditions. With another operation an attachment is to be made, or by a bone resection a knob can be formed. In a case where the muscles were too short to be sutured over the section of the bones, Wierze-

jewski took advantage of strips of fascia taken from other parts of the body to form artificial tendons and to unite antagonistic muscles.

*Kineplastic Transformation of Old Stumps.*—Although the muscles of an amputation stump, made according to one of the classical methods, after a while lose their power of contraction by undergoing a more or less extensive atrophy, still many stumps keep a sufficient degree of nutrition to permit a successful formation of kineplastic motors. The first cases were those of De Francesco and Von Wreden. In taking into consideration such cases, the surgeon should form the motor according to the circumstances, by taking advantage of the muscles which have better kept their power.

*Amputation of the Lower Limb.*—In amputation at the ankle, the Codivilla operation may be taken as an example. In order to avoid the inconvenience that Putti experienced in his case, it would be better to form the anterior motor as a loop. But if the knob is preferred, it should be larger, and possibly with some bony inclusion according to the rules of free transplantation. For the amputation at the knee-joint a loop, made by suturing the extensor and the flexor tendons, keeping the patella in contact with the condyles, is the simplest operative method, as it has been successfully used by Putti. Besides, all the amputations at the superior third of the leg, as all the osteoplastic amputations at the knee-joint, may be used for kineplastic purposes by tunnelling the quadriceps tendon or the flexor muscles.

Dalla Vedova, in his operation, mobilized and transplanted on the cut surface of the femur (supracondyloid amputation) the *anterior surface of the condyles*, with their cartilaginous layer turned down. The patellar ligament was sutured to the flexor muscles behind, consequently the patella acquired a horizontal direction and could execute movements on the displaced condyles.

A movable kinematic cuff, with a simple muscular loop, may be obtained even in cases of supracondyloid amputation when the osteoplastic method cannot be used. In 1914, without having any intention of making a kineplastic motor, I performed a supracondyloid amputation of the femur in which, on account of a previous operation, no anterior flap was available. To cover the section of the femur, which was made just above the condyles (according to the aperiosteal method) and to have an eccentric scar, I was obliged to cut a very long posterior flap from the calf-muscles. As the anterior incision of the soft tissues was close to the superior border of the patella, I made a very exact suture of the posterior muscular flap to the quadriceps tendon. The cuff showed, a few weeks later, such extensive voluntary movements that it could have been easily capable of transmitting



motions to an artificial leg. Unfortunately, the patient refused any other operation and left the hospital.

With the exception of the Pieri case, there has been no application of the method for the amputation at the inferior third of the leg. As a method of election, Pieri proposes to use the gastrocnemius tendon to form a plastic motor and give plantar flexion to the artificial foot. It is worth while to consider this suggestion, as it can be the source of successful application. He describes the following operative plan: "Cutaneous incision to provide a wide, anterior-posterior-external flap, the basis to be an inch below the point where the bones will be sawed, the length a little more than the diameter of the leg. In this flap, a little behind the fibula, a longitudinal incision is made. The consequence will be the formation of two flaps, one anterior-external, containing the anterior muscles, and one posterior, containing the triceps. After the section of the deep muscular layers, the bones are sawed and the exterior flap is used to cover the bones. The posterior flap, by means of small incisions, will be fitted so as to completely cover the calf-muscles and the tendon. This will be subsequently fenestrated or transformed into a knob."

The forming of an attachment to transmit motions to the prothesis is a very important step of the operative technic. The difficulties and unsucccess of various surgeons has already been discussed. By imitating Ceci's operation, it would be wise to form the button-hole of the loop, in a second operation, as Alessandri proposed. Even in other types of operations, one should divide it into two stages, which would favor greatly the final result. One of the best ways to form the attachment is the tunnelling of the muscles: the steps of this operation are shown in Figs. 13-16. Another form of attachment is the infundibulum, which is made by an artificial intraflexion of the skin in the underlying tissues. I do not know if this form of attachment, devised by Vanghetti, has had any practical application.

*After-care.*—"To prevent the effect of the muscular retraction, one must substitute for the natural insertion of the muscles, a new one either inside or outside of the stump" (Vanghetti). The after-care should try to obviate the secondary retraction that takes place more or less slowly after the amputation and is due to the atrophy for lack of function. This retraction, while it does not prevent a certain degree of work of a well-formed motor, can greatly reduce its power of contraction. The postoperative care is capable of reducing the loss of function or of almost recuperating it. Plastic motors with an internal attachment to the bones do not require any immediate after-care, as any retraction is prevented, but the stump should

be massaged and cared for, until the secondary operation is performed. In forming tendinous loops or knobs, it is useful to take some measure against the retraction which is favored by the long healing period. The majority of surgeons have tried to keep the muscles under tension by securing the tendons with silk strings which were passed outside of the wound and fastened either to the dressing or to an extension apparatus. The strings were removed when the wound was strong enough to permit the executing of regular exercises. Another way to keep the muscles under tension is to apply along the stump stripes of adhesive plaster and make traction on them. Such a procedure has been also used by Stropeni and Pellegrini to form, without any operation, a knob at the end of amputation-stumps.

#### CONCLUSIONS

1. The kineplastic amputation (Vanghetti's method) is such a modification of the operative technic that it makes possible the transmission of voluntary movements to the prothesis, thus realizing a true vitalization of the amputated members.

2. This method should be applied whenever possible, especially in the amputation of the upper limb.

3. In performing amputation of the upper limb, one should always have in mind the possibility of a future kineplastic transformation of the stump.

4. Secondary kineplastic operation should be favored and possibly performed in institutions where at the same time the artificial member could be constructed and fitted.

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## SPLINT FOR THE TREATMENT AND TRANSPORT OF CASES OF FRACTURE OF THE FEMUR

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THE treatment of fracture of the femur from a military standpoint is an entirely different procedure from the treatment of the same condition in civil life, because in military life the primal object of medical corps and of hospitals is not entirely humane but are maintained to hasten the return to active duty of men wounded and to conserve bodily function to the end that they may once again be of service to the military establishment. Other ends must be sacrificed to this one first great purpose, especially during a war of magnitude where conservation of man power will be, in the end, the deciding factor.

Imagine a soldier with a simple Colles' fracture of the wrist treated for from four to six weeks by the old method of retention splints, taken off once a week and no motion instituted at the wrist until the final removal of the splints. Some cases are so treated at the present time, resulting always in disability which lasts from six months to a year, when we know that, with immediate passive motion and with removal of the splints early, there should be few cases of Colles' fracture without full motion at the wrist in four weeks. In fact, the motion ought never to be lost even from the first. The treatment of fractured femurs cannot be expected to show such beautiful results as may be obtained in Colles' fractures, because of the forced immobilization and, second, because weight-bearing is a necessity and therefore firm union must result before such weight is allowed to fall upon the fractured member in order to prevent subsequent deformities, but there is little doubt that our main fault has been the use of retention apparatus extending over too long a period of time even in fracture of the femur. Treatment of fracture by the old method, straight position and weights pulling from the skin surface of the leg overcoming deformity and overriding only by partially paralyzing the muscles whose pull serve to perpetuate the deformities, causing injury to joint ligamentous structure by their long continued pull, especially at the knee, is to treat this form of fracture without any consideration for the anatomical structure of the thigh and leg and of the mechanical problem which is to be overcome. Undoubtedly we have had fair results in spite of our treatment because nature is, after all, the best reparative surgeon and it makes up for many of our shortcomings and with time corrects many of our mistakes.

In the proper treatment of fracture of the femur, with or without external wound or damage to soft tissue, there are many features to be considered; but they are not particularly complex; in fact, they are extremely simple. A fracture of the femur without impaction anywhere below the

trochanters presents the same problem whether just below the trochanters or lower down in the shaft. In a word, the fixation or stabilizing factor of the thigh has gone out of business, allowing the muscle pull to continue in the various directions exerted by these forces when the bone was intact and acted as a restraining or coördinating element upon that pull.

A fracture of any portion of this rigid shaft is influenced in position by the various pulls. First, the action of the gastrocnemii below acting on the lower end of the femur tends to pull the lower fragment backward. Second, the pull of the biceps and semitendinosus and semimembranosus tends to pull upward the lower fragment; the semitendinosus and the semimembranosus to a lesser extent also tending to rotate the lower fragment inward. Third, the action of the psoas and iliacus has a tendency to pull upward and inward the upper fragment and also to rotate the upper part outward. A certain amount of rotation outward of the upper fragment is present in every fracture below the insertion of the psoas and iliacus. The only muscles which could rotate it inward to oppose this pull would be the gluteus medius, and it does so to a slight extent, but not enough; the semitendinosus and semimembranosus have lost their ability to oppose this rotation outward of the upper fragment because of the solution of continuity of the bony shaft, and therefore are unable to exert any force upon the upper fragment rotating it inward. Fourth, the gluteus maximus would tend also to rotate the upper fragment outward should the solution of continuity be below its insertion into the femur. The rectus also helps the semitendinosus and semimembranosus and biceps to pull upward the lower fragments. Fifth, the adductors tend to pull the lower fragment inward and upward, but also to counteract the pull of the semitendinosus and semimembranosus tending to rotate the lower fragment inward unless the fracture is low down, when they tend to pull inward the upper fragment; but also assist all the other muscles in rotating it outward. Therefore, while we must consider the forces acting as dependents upon the position of the solution of continuity of the bone, in the main, we may say that the tendency is for the upper fragment to be pulled upward, flexed and outwardly rotated and the lower fragment to be pulled backward, inward and upward and if anything rotated inward.

Obviously, there remains only to be considered the proper position of the leg in order to overcome the pull of these different forces. Such a position is only to be obtained by flexion at both the knee and the hip. Flexion at the knee puts the gastrocnemii out of action and renders *nil* the backward pull upon the lower fragment. Flexion at the knee also puts out of action the tendency of the biceps and semimembranosus and semitendinosus to pull up the lower fragment and of the semitendinosus and semimembranosus to rotate inward the lower fragment.

Flexion at the hip renders *nil* the pull of the psoas and iliacus in its tendency to flex and rotate outward the upper fragment and vitiates the pull of all the gluteal muscles except the gluteus maximus. The pull of the

rectus goes out of action. The sartorius and gluteus medius are relaxed, the great thick band of fascia, or iliotibial band, is no longer tense. Remains only the quadratus, the gemelli, the obturator, externus and internus, all tending to rotate outward the upper fragment, and the upper fragment of such a fracture is always, in fact, rotated outward.

There is relaxation practically of all the muscle groups in the entire thigh and a much lighter weight will now serve to pull the broken femur into alignment and keep it there, and we have only to take into consideration this outward rotation and slightly rotate the leg and foot outward to meet the rotation in the upper fragment to secure perfect alignment. In certain cases a heavy weight attached to the leg in the straight position works, as seen in the Buck's extension and Hamilton long splint methods, or modification of it, but it works only when the weight is made heavy enough to overcome, after a time, the pull of these various muscles and practically paralyze them. It is a long time before they recover their tone. In cases where transport is not considered the Hodgen splint acts well, but after a few weeks, when change of position can be considered, especially because it is better to consider some motion to the knee as soon as this is feasible, there is no method of making this change without discarding the Hodgen and changing to an entirely different form of apparatus. After three weeks in the flexed position there is callus enough to hold the ends of the broken femur while we move the knee and lower it to a new position much less flexed, or even to the straight position with a weight attached to the foot for a moderate extension during several weeks longer. The movement at the knee at this time is advantageous, as most femur cases complain of the knee more than anything else because of the enforced immobilizing and the time of the weight extension which has pulled the ligamentous structure of the knee much too long and caused damage. With the Hodgen splint it is some proposition to make this change without entire relaxation of the pulling force and as yet we have not believed that this is advisable to do at such an early date. What can be done for these cases of fractured femurs which must be moved from place to place as must be done now that war has come with its multiplicities of problems of transportation?

With the splint which we have devised we believe we have simplified some of the problems of the treatment of the ordinary case of fracture of the femur and have also made provision for the treatment of these cases which will need to be transported to a base. The splint is made with two steel side-bars attached to a well padded ring which fits about the thigh high up. The padding is extra heavy and also extra padded with felt or sheet wadding when the ring comes into play as when it is used as a transport splint.

The ring is made of copper 1 inch in width by  $\frac{1}{8}$  inch in thickness, which allows it to be moulded to fit the points of pressure, and it is then heavily padded. The two side-bars are jointed near the ring to permit of changing the position of the bars, either angled or straight.

Swathes of cotton cloth hold the leg in place and may be made additionally secure if needed by the ordinary bandages. The special binders made for the splint if used instead of bandages are caught by flare side pieces bent back over each rod and pinned to the side. This arrangement allows the remaining tails to be strapped across the front of the leg. This is simple where for any reason frequent dressings are necessary. Three are usually

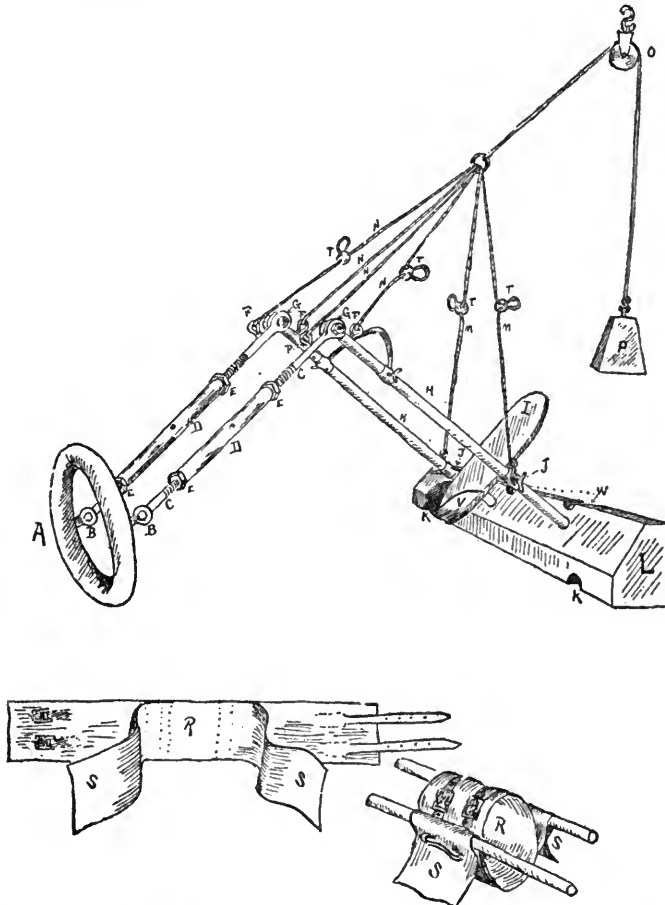


FIG. 1.—The Stevens femur splint. Three sizes of ring to each splint A, ring which is padded; B, joint of side-bar; C, side rod; E, check-nuts; D, turn-buckles; F, loop for cord; G, adj. joints; H, leg side-bars; I, adj. foot-piece; J, lock nuts; K, grooves for bars of a stretcher; L, matrix (wood); M, cord for support of leg; N, cord for extension; O, pulley; P, weight; R, canvas strip; S, side flaps to be pinned over side-bars, leaving ends of canvas strip free to be carried over front of leg; T, cord adjusters; V, heel rest; W, grooves in wooden rest for rods of splint when used in straight position.

enough for the support of the leg and two more for the thigh. On each side-bar is fitted a turn-buckle to be used always in transport and also in ordinary cases to give extra firmness to the extension, but in the treatment of these cases, not in transport, it is neither necessary nor advisable that there should be any pressure.

A foot-piece which is adjustable to any length of leg runs on the lower



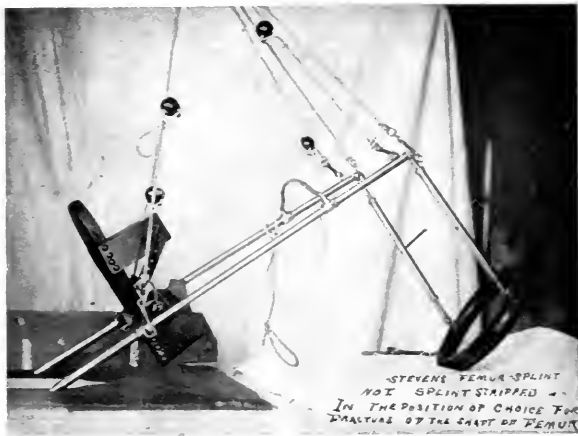


FIG. 2.

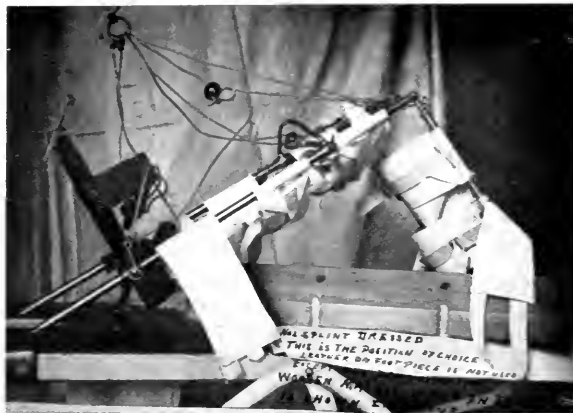


FIG. 3.

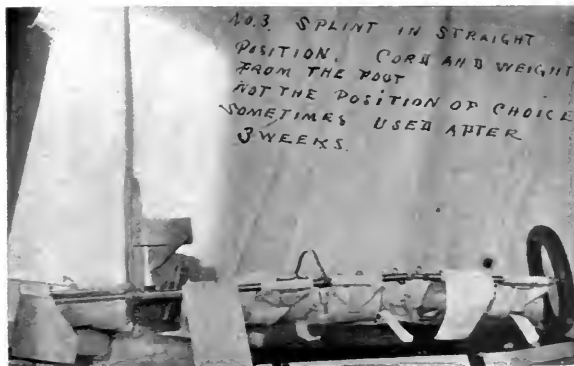


FIG. 4.

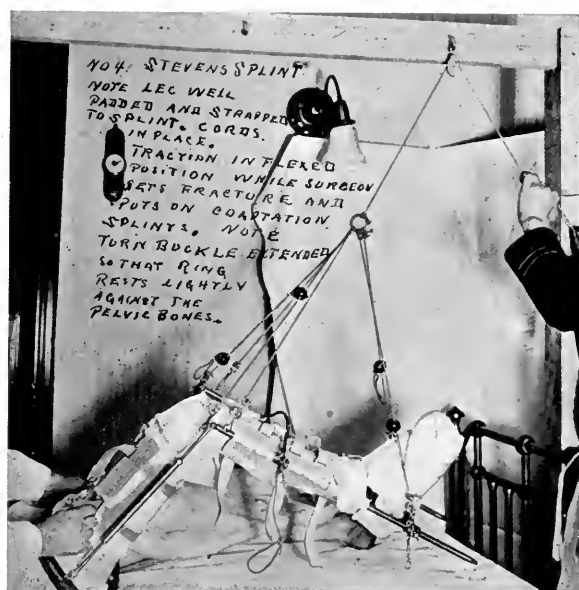


FIG. 5.



FIG. 6.



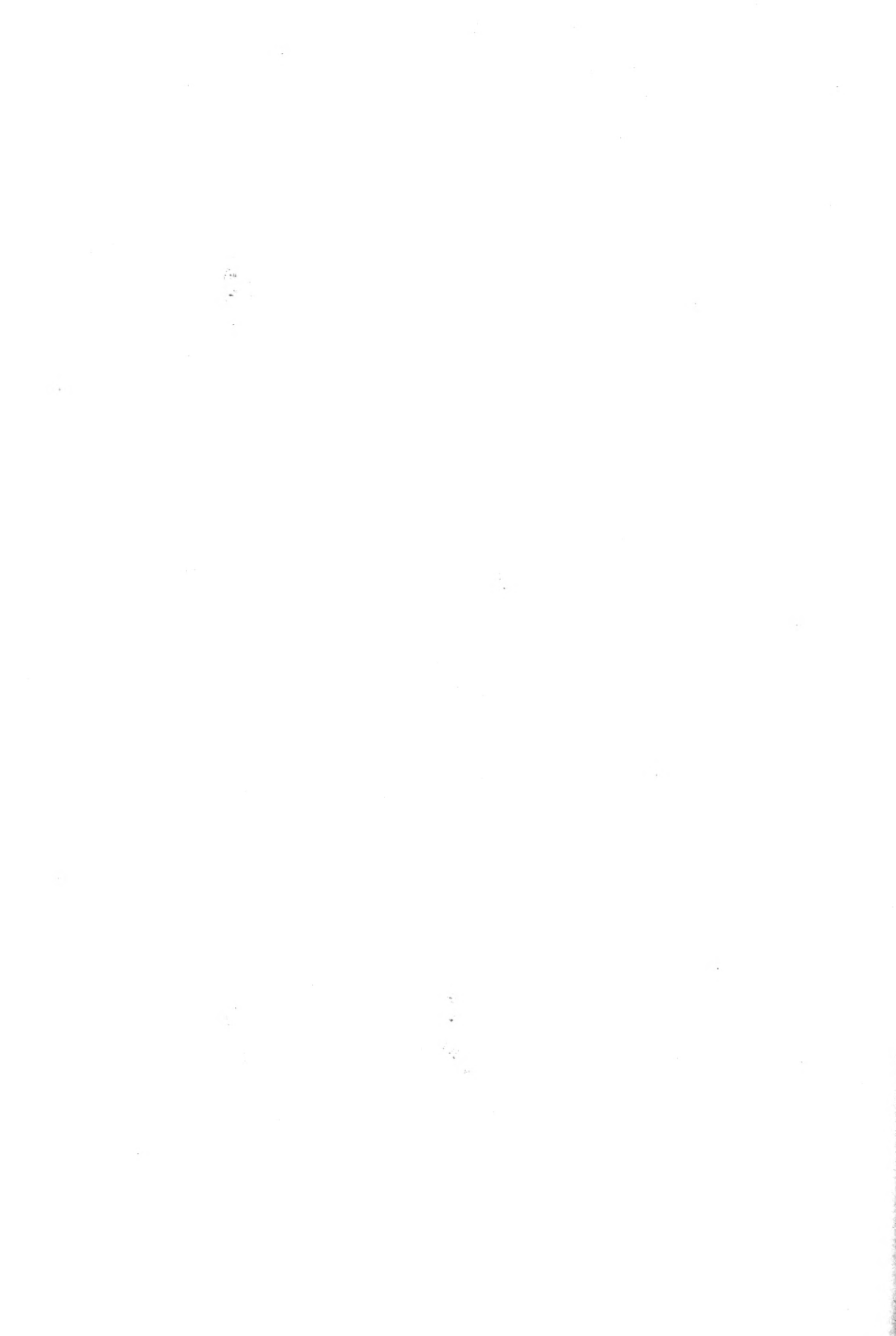
FIG. 7.



FIG. 8.



FIG. 9.



side-bars, and this foot-piece is padded to allow for the pressure of the foot and the inequalities of the dorsal surface of the foot. The splint is assembled. The leg with the broken femur is slipped through the padded ring until the ring rests upon the pubic bone and the tuberosity of the ischium. The foot-piece is adjusted and either strapped or bandaged to the foot, and the leg is firmly bandaged in place between the lower side-bars. With the leg strapped firmly to the splint and the foot to the foot-piece and ropes in place on the splint, the rope is carried over a pulley above the bed. The thigh is flexed at the hip and also to a right angle with the knee, and the rope entrusted to an assistant who exerts pull enough to reduce the fracture. Ether is seldom necessary. The fracture is manipulated by the surgeon and, if no external wound is present, a coaptation splint over padding is applied. With the pull still continued the turn-buckles on the thigh side-bars are extended so that the ring just touches the pubis, ischium and just below the anterior superior spine. The side straps are adjusted to fit the thigh in this position. A weight of 15 pounds is attached to the cord and the entire thigh and leg are left swinging clear. Ropes are so arranged that necessary amount of rotation is present and the proper arrangement of the turn-buckles assures 10 to 15 degrees of abduction, but this may be left to the individual surgeon.

Sometimes a scale is inserted in the pull to note the number of pounds which are necessary to swing the buttock just free of the bed, where one does not wish to use a pulley and weight. Where reduction of overlapping has not been accomplished in the first instance, as is possible in most cases with the thigh in this position, the pull of the rope above the knee exactly in line with the femur will in a short time, coupled with the perfect relaxation, suffice to pull the bones into alignment. The splint should be so arranged that the thigh is held slightly in abduction, which is essential. The foot of the bed is raised to counteract the continuous pull. In a few days all shortening is overcome and a new adjustment of the splint made by a turn or two of the turn-buckles to lengthen the splint but not enough to bring about any pressure on the pubic bone or tuberosity of the ischium. Should there arise the necessity of transporting this case before cured, the turn-buckles on the side-bars are turned to give extension after the check-nuts are loosened and the splint is extended between the thigh ring and the knee so that the femur is held rigid, the check-nuts are tightened and the splint is lowered to the bed. A piece of board two feet in length with perforations for the ends of the splint is provided to prevent rotation of the entire splint and leg while in transit.

Inversion or eversion of the foot is prevented by the foot-piece, and by raising or lowering either end of the wooden rest all rotation desired may be secured.

In transporting these cases the transport is made with the thigh in the position of flexion, holes in the matrix, or wooden rest, having been made to fit the handle bars of the stretcher.

From this he is transferred easily to the hospital train or boat and carried comfortably to his final destination, where he is again transferred to bed; the splint suspended, the pressure on the pubis and ischium released by a few turns of the side turn-buckle. Any dressing en route is easily made, in case of open wound, by simply unbuckling one or two straps, dressing the wound, and replacing them.

The pressure is, of course, against the pubic bone and the tuberosity of the ischium and also just below the anterior superior spinous process of the ilium in this flexed position, and too much extension must not be used. Neither is it advisable, necessary, or possible, to continue this form of extension for the entire treatment of the fracture, although a surprisingly low pressure suffices to keep the bone in place, once reduced. But this feature of the splint is solely a transport feature without necessitating a change of splint at any time, and the pressure of transportation could hardly be considered necessary for any considerable length of time. It would easily be borne without much discomfort for a number of days.

If the apparatus is used with weight extension the first weight should be 15 pounds and this increased or reduced as necessary; if used with scale, just sufficient to pull the patient's buttocks well off the bed.

In the suspended position, which should be the position of choice at least for the first weeks, the fracture if open is entirely accessible. The pull must be in line of the thigh and the foot of the bed raised to prevent the patient being pulled out of position.

After three weeks of suspension, soft callus is already formed and the leg may be (if wished) lowered to the straight position and extension made by attaching a rope to the lower side of the foot-piece and extension continued as long as desired, the foot-piece being allowed to slide on the bars in this position.

If desired, treatment may be instituted with this splint in the straight position and is simpler than the older methods, the extension being from the foot-piece, the foot-piece unlocked being left to slide upon the side-bars, and transport is rendered easy in this position by use of the turn-buckles, more force, however, being required than in the flexed position, because of the necessity of overcoming the muscle resistance. The base reached, the weight is again applied, still in the straight position, and treatment continued. The wooden cradle is used in this position to give the necessary rotation and to give firmness and stability to the apparatus.

# HOSPITAL BED DESIGNED FOR MILITARY HOSPITALS

WITH A SPECIAL MODEL FOR CIVIL HOSPITALS

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A BED is simply a square frame with a more or less elastic surface supporting a mattress set on legs. The same is true of beds used for the sick and injured, but the ordinary bed is necessarily a heavy and awkward piece of furniture which does not lend itself readily to the demands of modern hospital treatment.

Every one appreciates the difficulties encountered in lifting serious cases in and out of bed, in transporting beds even on wheels, in securing elevation of the foot or head of the bed, in obtaining a satisfactory sitting or Fowler position, in applying artificial heat, in treating fractures, and in meeting many new conditions which constantly arise. The ordinary bed was not designed for such peculiar requirements, but for sleeping purposes only.

In the treatment of fractures where special apparatus and devices for traction are employed the inconveniences are especially obvious. In fact, the modern hospital bed should be a good deal more than a bed. It should be possible to transport bed and patient with ease, to place patients in various positions with little effort, to eliminate unnecessary handling of the sick, to save in the matter of labor with corresponding increase in efficiency and to provide more effective mechanical treatment for fractures. With the development of röntgenology, it should be possible to submit fractures to fluoroscopic examination in bed.

In military surgery the question of hospital beds is an important one. There is the matter of providing and transporting thousands of beds which take up considerable tonnage space. There is also the labor of installing this equipment, especially important where mobility is concerned, in mobile units when hospitals are bombed, or military necessity calls for change of location. Moreover, the hospital personnel is not only limited and labor must be utilized to the best advantage, but a great strain is put on the personnel when the wounded are received in large numbers at irregular intervals. There is always the danger of fire in the wooden barracks now generally used for military hospitals, and to remove bed-ridden patients, especially fracture cases, often tied to their beds, is a difficult undertaking. In a hospital with a thousand or more beds the labor of moving the wounded to and from operating room or Röntgen laboratory is very great. The seriously wounded require extra care. Fresh air treatment has been found most beneficial, but to lift patients out of bed and carry them out is a tedious process and often impossible in the fracture cases which need it the most.

FIG. 3

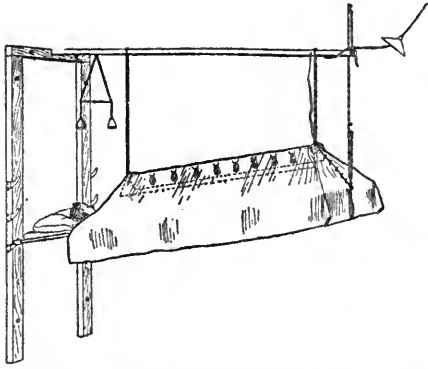


FIG. 4

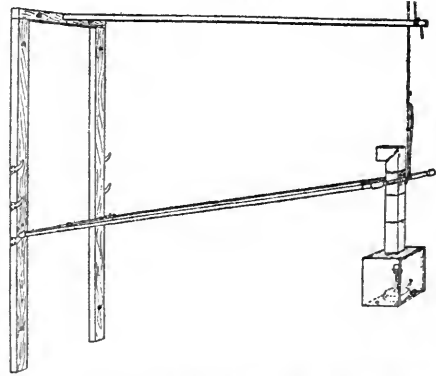


FIG. 3.—Showing method of using bed in cases of severe wounds associated with surgical shock. In many of the British and French hospitals, unusual attention is given these cases, a special "resuscitation" ward being set aside, and electrically heated beds used. Elevation of the foot of the bed, absolute rest and artificial heat are important factors in the treatment. Ordinarily elevation is obtained by placing various objects under the bed, but this entails a supply of numerous blocks and chairs, with which it is difficult to regulate or change the elevation and which encumber the floor. Electric heat is usually secured by means of a semicircular cradle lined with electric lights and resting on the bed. Considerable handling is usually required in moving these desperate cases from the ward to the operating room or X-ray laboratory. With this new type of bed the patient is moved without disturbing him in any way, elevation is obtained without floor supports and artificial heat supplied by a suspended tin reflector fitted with a row of electric lamps. This is easily adjusted as to distance from the mattress and gives unobstructed approach to the patient from either side for examination and treatment.

FIG. 4.—Bed showing artificial heat supplied by oil or alcohol lamp. It is customary when oil lamps are used to place them on boxes or stools, carrying the heated air through a small stovepipe up and under the bed clothes at the foot of the bed. This is rather clumsy in many ways. As a substitute a hanging stove has been devised which consists of a large tin box for the burner with a chimney made of discarded square tin cans. The stovepipe is suspended from the bed frame by strong hooks and maintained in the vertical position by being properly weighted below. As the foot of the bed is raised the chimney always remains in the vertical position and the lamp at the same distance from the bed. The pipe is carried inside the frame because the bed is extra long with an open space at the foot.

FIG. 5

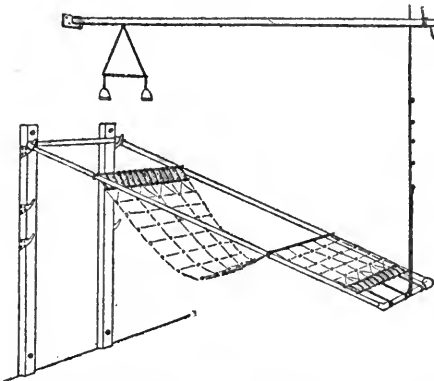


FIG. 6

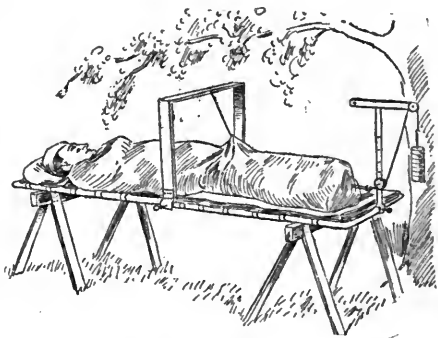


FIG. 5.—Bed showing Fowler position with head of frame raised and foot lowered. The sitting posture is obtained by having the row of coil springs at each end of wire mattress attached to two steel bars which in turn are secured to the ends of the frame by strong hooks. By placing another loose bar under the wire mattress at the bend of the knees and unhooking the upper bar, the mattress automatically assumes the position of a hammock chair. Both bars are held in place by small pins projecting from the side bars of the frame. The change to the horizontal position is made by lowering the head, raising the foot, and hooking the wire mattress over the upper end of the frame. This is accomplished by means of a simple lever. One distinct advantage of the sitting position as obtained by this bed is the fact that it has side bars which prevent the patient from falling out. With moribund, unconscious, and helpless patients it has not only been difficult to secure a satisfactory Fowler position, but it is often necessary to add lateral support.

FIG. 6.—Showing the ease with which patients may be taken out for fresh air treatment. Many cases of fracture with suppurating wounds are bedridden for months and are especially benefited by being taken out when the weather permits. It is a great advantage to be able to do this without moving the patient from the bed or disturbing the traction.



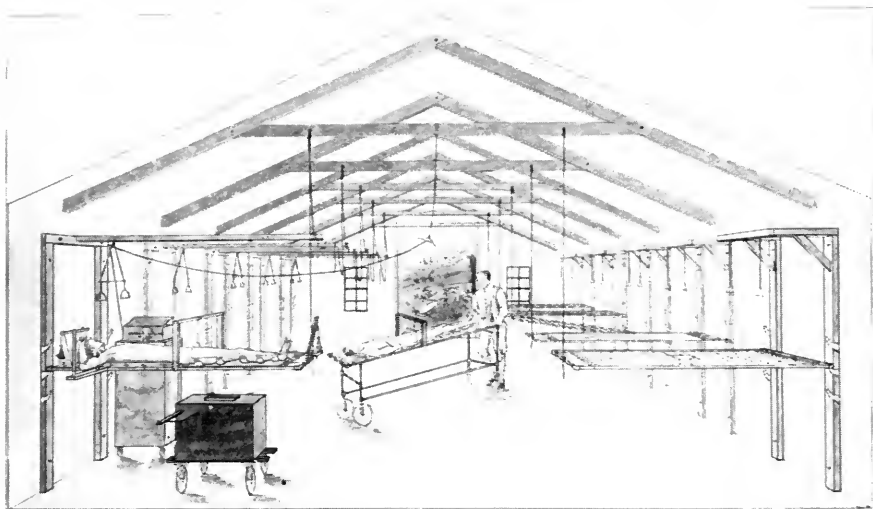


FIG. 1.—View of ward in "Santé" barrack showing new type of bed, which consists of a Bradford gaspipe frame secured at one end to wooden posts bolted to the wall and suspended at the foot by a rope to the rafter or ceiling. A set of iron hooks on the posts make it possible to raise or lower the head of the bed and a locking device holds the bed securely in place. The foot of the bed is elevated or lowered by means of the rope and a snap hook eliminates the use of knots and the danger of the rope slipping. Two forms of wooden frames are shown, but the more complicated one on the right has been abandoned. Both the wood and Bradford frames, being flat and light, are easily transported without crating, simply using the suspension ropes for tying the frames together in sets, and it is a simple matter either to install or take down the beds. Across the gaspipe frames may be stretched standard wire springs, canvas, or rope, as shown in the first three beds on the right. Mattresses made in two sections are used, so that one section may be removed for Röntgen examination. The floor space is entirely free and clear so that a portable X-ray tube stand may be wheeled under the beds, making X-ray examination in the wards, so much advocated by the French, quite simple. It also makes possible bedside fluoroscopy, so difficult on the ordinary bed, in the most advantageous position, from below, with unobstructed field for observation above the patient. A bar is hung over the bed from which are suspended handles by which the patient is able to lift himself, flasks for irrigation and Carrel treatment, electric bed warmers, etc. Supports for traction and suspension of the limbs in the treatment of fractures and wounds are attached directly to the Bradford frame. In this way the frame with the patient may be taken to the Röntgen laboratory, the operating room or out for fresh air treatment, without disturbing the limb or the traction. The beds are used to transfer patients from ward to operating room and from ward to ward. This saves the labor of lifting patients in and out of bed as well as much suffering and injury inflicted on serious cases. The wheel stretcher is simply rolled under the bed, taking bed and all, or the bed may be carried out by hand like a litter. In case of fire, a ward may be emptied very much quicker than when it is necessary to lift helpless patients from beds to litters, especially if encumbered with fracture apparatus or tied to the bed by weights and pulleys.

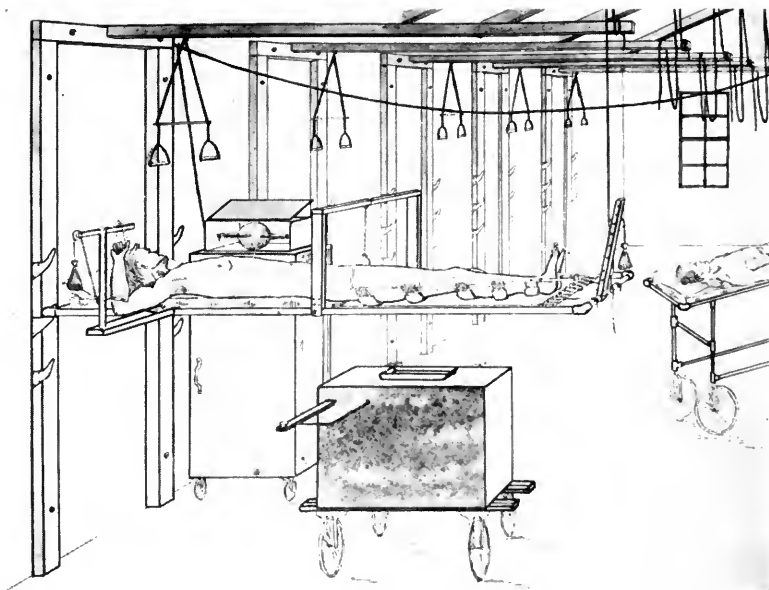


FIG. 2.—Section of Fig. 1, showing bed with attachments for fracture treatment and wheel trochoscope (designed by Capt. A. H. Busby, Chief of the Röntgen Laboratory, Base Hospital No. 9). The fracture attachments were designed by the author after an extensive experience in the treatment of military fractures among the French wounded, and have been fully described in a paper to be published at an early date. The idea has been to obtain effective fixation of the limbs in various positions with complete exposure for wound treatment, so essential in war fractures. Traction with suspension is secured with the Thomas splint, the Hodgens splint, the Balkan splint, with the Steinmann nail or the ice tongs, with the Finochietto stirrup, with the knee flexed, with the leg abducted, etc. In addition operation may be performed with the limb in traction and plaster cast applied upon the frame. A sling placed under the pelvis and fastened to the central bridge assists in the use of the bed pan and in the treatment of posterior wounds. The method of Röntgen examination in the ward, as planned by Capt. Busby, includes a portable Ledou Lebard coil, which takes the current from the ordinary lighting system and the simple trochoscope for directing the rays from below. Ordinarily this will be sufficient for routine ward work. When, however, the lateral view is desired, it is only necessary to attach a special frame to the side of the trochoscope and adjust a separate tube which is carried for that purpose. Whenever advisable, the patient may, of course be taken to the laboratory.

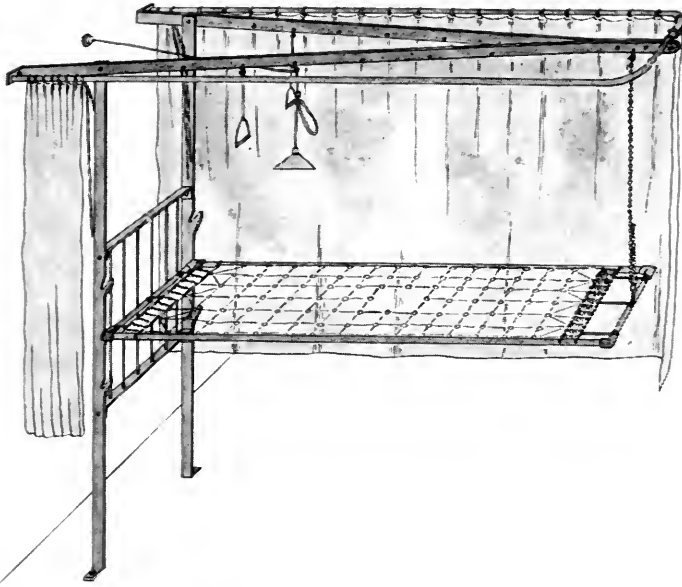


FIG. 9.—Special type of bed designed for civil hospitals. The Bradford frame is supported by two vertical posts set out from the wall and by a rope or chain suspended from two converging horizontal bars which are securely bolted to the wall and support the vertical posts. A separate curtain rod set well out from the sides of the bed support two curtains operated from the head of the bed, so that the patient may completely screen himself. A hole in the centre of the wire springs with a mattress in two sections may be utilized for special bedpan purposes. The open wire springs do not seriously interfere with horizontal fluoroscopy and if made of aluminum wire, the conditions for Röntgen examination of patients on the bed-frame are almost ideal. Holes in the bars over the bed provide convenient suspension for electric drop light, lifting handles for the patient, flasks for irrigation, Murphy drip, etc. A hinged, iron rod may be used to support the foot of the bed frame in place of the chain.



## HOSPITAL BED FOR MILITARY HOSPITALS

Following observations made in many French and British hospitals in 1916 and 1917, I have designed a new type of bed which Colonel F. A. Winter, Chief Surgeon, Lines of Communications, has authorized installed in one of the fracture wards of Base Hospital No. 9. The bed consists of an ordinary Bradford gaspipe frame which is supported at one end by posts bolted to the wall and by a rope suspended from

FIG. 7

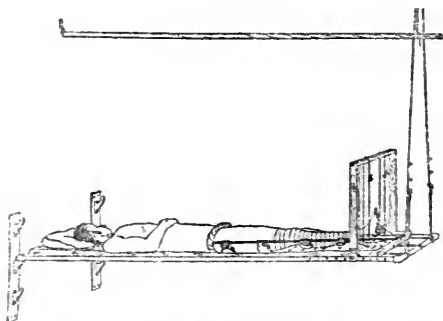


FIG. 8

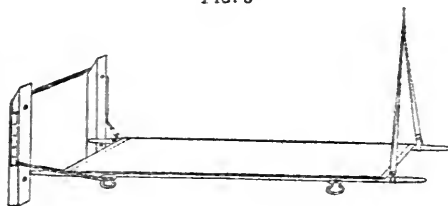


FIG. 7.—Showing bed with fracture bridge used to support the Thomas splint. This splint has become one of the most popular, especially among the British. It is particularly useful in the early treatment of fractures because early traction is very important and no other method relieves the pain so well. It is also valuable as a post-operative splint when cases must be evacuated to hospitals further from the front, and as a permanent splint when others are not available. This splint should always be suspended at the lower end when possible. A different form of wall bracket is shown, consisting of an iron plate with the hooks in one piece and a double rope at the foot of the frame. Simple beds constructed in this way would be suitable for the wards of civil hospitals.

FIG. 8.—Regulation army litter used as a bed. It has often been found necessary to equip barrack wards with stretchers instead of iron beds in emergency. These are usually placed on wooden horses, which in quantity are awkward to transport. By having a peculiar form of wooden cleats which bolt to the wall, it is possible to suspend litters in the same way as the Bradford frames, using the canvas carrying straps and a short piece of rope.

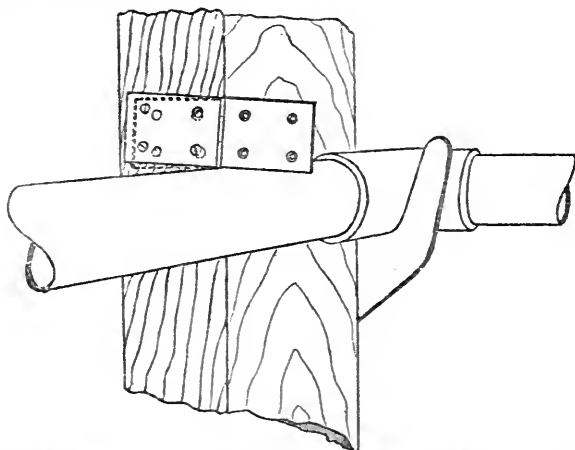


FIG. 10.—Ordinary hinge used to lock end of Bradford frame to wall brackets. These are put in on a slant so as to jam, making a tight fit.

the ceiling at the other end (Fig. 1). The head of the bed is adjusted in height by a series of hooks while the foot of the bed may be raised and lowered by means of a rope. A lock is provided for the head of the frame so that it is perfectly secure (Fig. 10). Standard wire mattresses, canvas or rope may be stretched across the bed frame. Fracture attachments for traction and suspension are fastened directly to the frame (Fig. 2). The wire or canvas mattress is arranged so that the Fowler position may be secured (Fig. 5). A horizontal bar above the bed supports lifting

handles for the patient, electric bed heaters, etc. (Fig. 3). The bed is six inches longer than the ordinary bed in order to give ample foot room for fracture cases. A special model of this type of bed is shown in Fig. 9, and a method for suspending the regular army stretcher for use as a bed is illustrated in Fig. 8.

The important features about this hanging bed without legs are:

1. It is simple, light and cheap.
2. It may be set up, taken down, and moved without unnecessary labor.
3. Various positions are obtained with little effort, the Fowler position, elevation of the head or foot of the bed, etc.
4. It is essentially a portable bed. A wheel-stretcher is rolled under the bed, taking bed and patient, or the bed may be carried out by hand.
5. It makes a satisfactory shock bed because the patient may be moved on the frame, artificial heat is easily applied, and elevation is simply obtained.
6. Fractures may be effectively immobilized, X-rayed in bed, or taken to the laboratory, the operating room or the lawn without interfering with the fixation of the limb.
7. The floor beneath the beds is free and clear, which makes it easier to keep the ward clean, and Röntgen examination at the bedside much simpler.
8. It is labor saving.
9. In case of fire patients may be removed quickly, each bed being taken out as a litter.

## THE TYING OF A SURGICAL KNOT

BY ARTHUR ROGERS GRANT, M.D.

OF UTICA, N. Y.

THE prevalent manner of making a transfixion suture and knot if analyzed appears very crude. It is slow and clumsy. It is unskilful. It has no uniformity and therefore it is often a "granny" and frequently broken. It is extravagant. It is the probable origin of the occasional infection, gloves being the carrier.

I believe that a critical consideration of the faults of common practice is justified by the fact that every surgeon must use transfixion sutures constantly and therefore my new technic is an advantage, in every way, over the older methods.

*The Old Way.*—The nurse tries the tensile strength of the thread with her hands, threads the needle with her fingers and adjusts it in the needle-holder. The surgeon picks up a tissue forceps or needle forceps in his left hand and, taking the needle-holder in his right, transfixes the tissue with the needle and pulls it through. He then lays his needle-holder down near his right hand and his needle forceps near his left hand and picks up the ends of his suture and ties the knot; it is then cut off by the assistant. The surgeon then picks up his needle-holder and his needle forceps and adjusts them all in his hands again and repeats the procedure, laying them all down and picking them all up again.

*A Better Technic.*—The instrument nurse threads the needle with sterile forceps, not touching the gut nor the needle with her gloves.

*Technic of the surgeon:* Transfix the tissue, pull the needle through with the needle forceps and catch the suture near the needle with the needle forceps in the left hand; pull on the left end with the left hand forceps until the right short end is only one-half inch from the point of transfixion. The long end should be proximal and the short end distal to the operator.

Lay the point of the needle-holder across and on top of the suture just below the tips of the needle forceps, pointing *upward* toward the tips of the needle forceps, and make a loop around the needle-holder.

Now catch the short end of the suture with the needle-holder, keeping its tips close to the site of the knot, while the left hand pulls the first half of the knot tight. Now place tips of needle-holder *beneath* suture and make a second loop which completes a reef or square knot.

If a true surgeon's knot is required, make two turns of the suture in the beginning, after which the second turn is made as before.

The advantages of this knot are obvious:

1. The knot is visible in the making and, as the hands are not in the surgeon's view, slipping or loosening does not occur.

2. The two ends of the thread are in alignment, therefore breakage is almost eliminated because necessary tension can be most delicately estimated.

# ARTHUR ROGERS GRANT

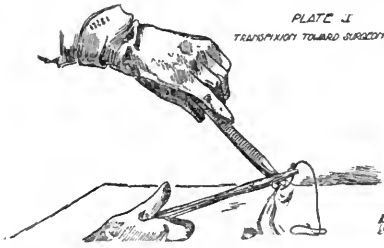


FIG. 1.

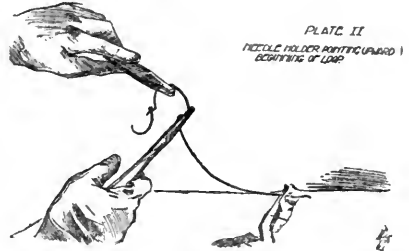


FIG. 2.

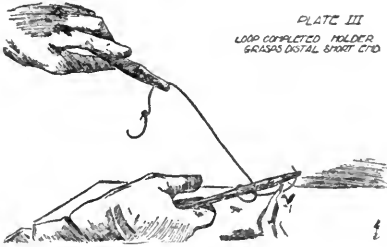


FIG. 3.



FIG. 4.

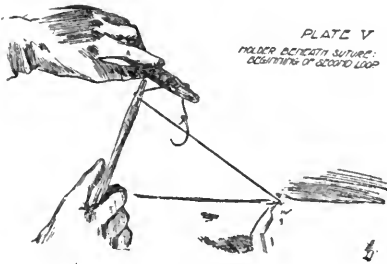


FIG. 5.

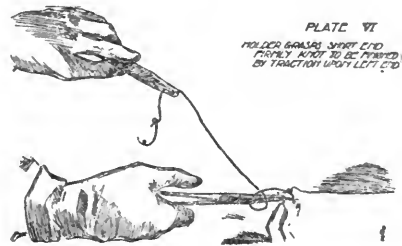


FIG. 6.



FIG. 7.

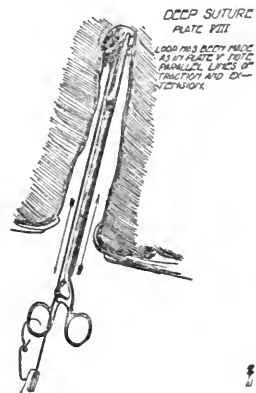


FIG. 8.



## THE TYING OF A SURGICAL KNOT

3. The directions of "first over then under" the thread, when the needle-holder makes the loop, always insures a square knot.

4. It is very smooth and once acquired makes a beautiful technic, because:

5. The instruments do not leave the surgeon's hands. Repeated interrupted sutures can be placed and tied without shifting.

6. And for the same reason it is a great time-saver without any semblance of hurry.

7. It is economical beyond belief; it is no exaggeration to state that one tube of catgut will tie as many knots as four tubes by the older methods.

8. It is universally applicable with any forceps, although I find that a Hagar or Ferguson type of needle-holder is best adapted. It is ideal when used with very fine sutures for the most delicate sutures in the eye, brain, etc.

9. Its placement in deep cavities is one of the most important features, because the short end, and the shorter the better, makes easy, important transfixion ligatures beneath the liver, in the depth of the pelvis and bladder, any place, in fact, where it is difficult to get a pair of big hands.

In placing sutures in very inaccessible regions a slight change in technic is advisable. Transfix tissue *away* from the surgeon so that when the ligature is drawn through the short end is proximal and the long end distal to the surgeon. Then make the first loop with the needle-holder *underneath the* suture; catch the short end with needle-holder and carry it down to, and then one-half inch distal to, the site of the knot.

Now hold needle-holder down firmly in this position and draw up as firmly with the long end: the ends are in alignment and the necessary opposing forces can be applied with the hands entirely outside the wound.

One could tie a safe knot by this method in the bottom of a bootleg.

10. "No-hand-touch technic."

When gloves were introduced it was believed that infection from hand contact would be eliminated. We know now that the gloves of surgeons and nurses are not always sterile at the close of operations.

While most catgut is above reproach, it is a good culture medium and many of the occasional infections come from handling of the strands by nurses or surgeons.

This method of tying knots furnishes a practical method of applying a "No-hand-touch" technic that is obligatory in many procedures.

After four years' experience with it in all varieties of general surgery I am sure that it is a refinement and an improvement upon older methods.

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# THE BIOLOGICAL AND CLINICAL EVIDENCE OF THE THERAPEUTIC VALUE OF RADIUM AND RÖNTGEN RAYS IN CANCER\*

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In a recent publication Isaac Levin and Barnet Joseph (*J. A. M. A.*, 1917, lxix, 1068) reported on a series of cases of carcinoma treated by radium and Röntgen rays in which a clinical arrest of the disease was accompanied by a complete absence of morphologic changes in the tumor tissue. The writers explained this phenomenon by the assumption that the radium and Röntgen rays may impair the proliferating power of the cancer-cells and consequently the clinical malignancy of the tumor without producing any change in the morphologic appearance of the latter. They maintain that it is probable that the first effect of the rays on every malignant tumor consists in the inhibition of the proliferating power, in the *sterilization*, as it were, of the cancer-cells. The degeneration and destruction of the cancer-cells and the formation of the sclerotic connective tissue takes place subsequently, under the influence of the rays. The writers further assert that the degeneration and death of the cancer-cell may not be directly due to the action of the rays, but may take place in the natural course of the life cycle of the cancer-cell. This cycle consists in every plant and animal cell of *youth*, or period of development; *maturity*, or period of function; and the *senility*, or period of degeneration, which gradually leads to death. In normal cells of parenchymatous organs, like the liver or kidney, the first period is usually completed during embryonic life of the organism or at a very early age; the second period continues through the whole life of the organism, and the third period is attained at its old age or near its death.

The life of an individual cancer-cell is short. It changes rapidly from an embryonic into an adult and immediately into an aged, degenerated cell, and this process takes place continually irrespective of any extrinsic aid. But as a rule the cancer-cells are rejuvenated before they reach senility. The reason for it lies in the fact that each cancer-cell divides into two daughter cells, before the original mother cell reaches its maturity. When the

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\* Read before the Surgical Section of the New York Academy of Medicine, December 7, 1917.

rays arrest this proliferation, then each individual cancer-cell without any further outside aid matures, degenerates, and ultimately dies.

There is ample clinical and experimental evidence of the fact that the radium and Röntgen rays produce a direct inhibitory action on a certain class of cells. Moreover, the rays, when a correct quantity and quality is selected, may affect deeply one class of cells and produce no influence whatever on all other cells of the organism. The specific action of the rays on the testicles and ovaries is characteristic of such a direct influence of the rays on a certain class of cells.

Malignant tumors of vertebrates and man, on the other hand, are complex structures consisting besides the tumor-cells of connective-tissue stroma and blood- and lymph-vessels, and the mechanism of the action of radiations on cancer can therefore not be determined with certainty. Some observers maintain that the extensive formation of sclerotic connective tissue which is the generally observed change in tumor-tissue under the influence of radiation is its only direct effect. In accordance with this opinion, the destruction of the tumor-cells is secondary and due to lack of nutrition, and the rays exert no direct influence on the cancer-cells. In view of this complexity of the phenomena in human cancer it seemed desirable to study the effect of the rays on conditions analogous to human cancer but more simply constructed. The crown gall seemed to the writers to be an ideal structure for this purpose, and the present publication is based on a study of the influence of Röntgen rays on the development of the crown gall.

Crown gall is a tumor-like formation found on a great variety of plants. The name "crown gall" is given to the condition because the growth frequently appears on the part of a plant where stem and root join, which is called the crown of a plant. The disease is caused by a parasite (*Bacterium tumefaciens*) and may be induced artificially by inoculating the plant with a pure agar culture of the microörganism. Fig. 1 shows a crown gall on the lower part of a ricinus plant artificially produced by the writers. The technic consists in pricking the plant with a needle loaded with a drop from an agar culture of the *Bacterium tumefaciens*. For this inoculation as well as all of the present study ricinus plants and agar subcultures of *Bacterium tumefaciens* were used. The seeds for the former and the primary culture for the latter were obtained through the courtesy of Dr. Erwin F. Smith, of Washington.

Doctor Smith, who studied the condition continually for the last ten years, is of the opinion that the disease is completely identical with animal and human cancer. Moreover, from the fact that crown gall is a parasitic disease he deduces the theory that animal cancer is also a parasitic disease.

It is outside of the scope of the present article to discuss the reasonings of Doctor Smith and compare them with the viewpoints of pathologists and workers in cancer research. But nobody can deny that there is a nearly complete analogy between the two conditions. Crown gall as well as cancer is a new growth caused by a continuous limitless proliferation of a

group of cells within a tissue, the normal cells of which ordinarily do not proliferate. As a result of the rapid proliferation the new cells remain young and undifferentiated. Fig. 2 represents a microphotograph of a crown gall developed subsequently to an inoculation of an agar culture in a ricinus plant done by the writers. The tumor developed and grew within the stem cells of the plant. One notices that the cells of the gall are much smaller and richer in protoplasm than the normal cells of the stem. Thus, the basic structural unit of the crown gall, its proliferating cell, behaves in every respect in the identical manner as a cancer-cell. The fact, on the other hand, that plants do not possess any true blood or lymph circulatory system simplifies the structure of this type of growth. The crown gall practically consists only of tumor-cells and therefore, as stated above, presents an ideal subject for the study of the direct biological action of the Röntgen rays on tumor-cells.

The method of raying the plants was identical with the technic described by the senior writer in "X-ray Therapy of Human Cancer" (Isaac Levin, *Medical Record*, December 9, 1916). A preliminary set of experiments has shown that with this technic normal plants were not disturbed by the X-rays in their growth and development. Fig. 3 shows two ricinus plants of the same age and grown under exactly identical conditions of light, temperature and soil. The plants look nearly alike, though one was rayed and the other not. Preliminary inoculations by the writers with the *Bacterium tumefaciens* of a large number of ricinus plants have also shown that the inoculations were uniformly successful and were followed by the development of a large crown gall.

For the study of the influence of the Röntgen rays on the development and growth of the crown gall 43 plants were inoculated with the microorganism, and the inoculation was followed immediately by Röntgen ray treatment. The treatment was given to each plant 6 times in the course of two weeks at intervals of two days. Simultaneously with the radiated plants control plants of the same age and size were inoculated with the microorganism from the same subculture. Four weeks after the inoculation a final examination was made of the plants and tissue taken for microscopical examination. At that time all the control plants had developed a large crown gall. The majority of the radiated plants, on the other hand, either showed no trace of the inoculation, or a minute swelling appeared at the place of inoculation. Fig. 4 shows a control plant with a fully developed crown gall and a radiated plant with a minute swelling.

In ten of the radiated plants there developed a small stunted growth. Fig. 5 shows such a growth. The microscopical study of the radiated plants revealed an extremely instructive condition. Not only the stunted growths, but even the minute swellings which on gross inspection were thought by the writers to be scars caused by the mechanical injury of the needle prick, showed the presence of morphologically unchanged crown gall cells.



FIG. 1.—Two ricinus plants. *a* shows a crown gall in the lower part of the stem.

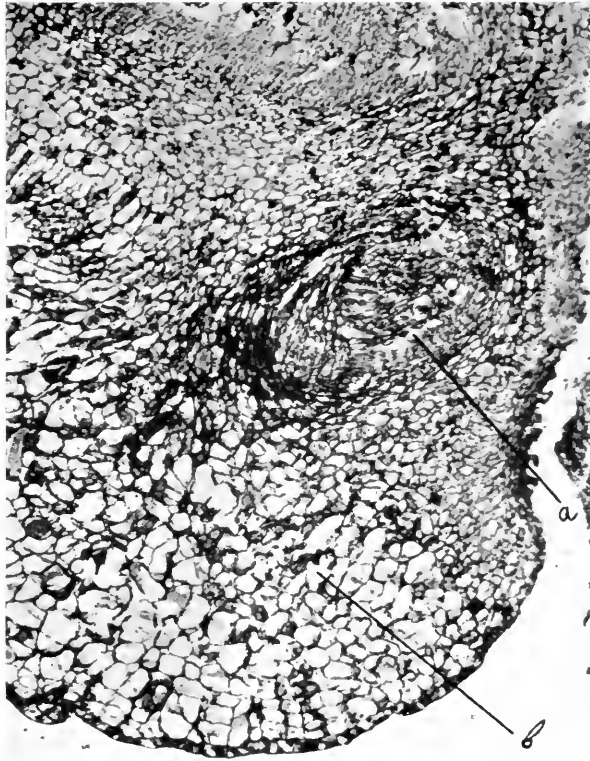


FIG. 2.—Microphotograph of a crown gall. *a* shows tumor cells; *b*, normal stem cells.



FIG. 3.—To the left an X-rayed plant; to the right, a control plant. Both plants normal.



FIG. 4.—To the left an inoculated and X-rayed plant showing at *b* a minute swelling at the point of inoculation; to the right an inoculated control plant showing at *c* a fully developed crown gall. The plants themselves show no abnormality.



FIG. 5.—An inoculated and X-rayed plant; shows at *b* a stunted crown gall.



FIG. 6.—Microphotograph of a cross-section of a petiole. Shows at *b* a small group of tumor-cells.



Fig. 6 shows a microphotograph of a cross-section of a petiole (stem of a leaf) at the level of a swelling. It contains a small group of characteristic gall-cells. This finding clearly corroborates experimentally the opinion of Levin and Joseph stated above that the primary effect of the radium and Röntgen rays on malignant tumors consists in the inhibition of the proliferating power of the tumor-cells and not in their direct destruction.

In the present experiments this mechanism appears as the only possible mode of action. The raying was begun immediately upon inoculation with the express purpose of studying the action of the rays on the microorganism itself. It is evident that the rays did not destroy it, since it was able after the raying to alter a certain group of normal cells of the stem into gall-cells. Then under the influence of the rays these few tumor-cells did not proliferate and develop into a full-grown crown gall.

The results of the present experimental study as well as the clinical investigation of Levin and Joseph prove that the morphologic appearance of radiated tumor-tissue is not an absolute criterion of the therapeutic effect produced by the action of the rays on the tumor. The biological or clinical evidence of the arrest of growth or diminution of the size of the tumor is of undoubted value. A complete destruction of the tumor-cells which takes place in many cases even in large tumor masses presents undoubtedly the most perfect result of radiotherapy. On the other hand, negative morphologic findings do not preclude the possibility that the tumor was influenced by the rays. Radiated and non-radiated carcinoma tissue may have the same microscopic appearance, and still the former tissue is sterilized and may have lost to a great extent its power of proliferation and consequently its clinical malignancy.

The practical conclusion to be derived from these clinical and experimental investigations is the following: It is advisable to radiate malignant tumors not only after an operation, but in a certain class of cases also before an operation so as to sterilize and inhibit the proliferation of those cancer-cells which may be left behind or transplanted elsewhere in the course of an operation. Such a procedure does not prolong appreciably the time preparatory to an operation and presents no danger to the patient. The fear expressed by some clinicians that the raying may occasionally irritate and increase the rate of growth of the tumor is unfounded. There is no clear experimental evidence of such irritating action of the rays on young proliferating cells. The result is always an inhibition. The clinical evidence of the existence of an irritating action of the rays is also very vague and not convincing. One must keep clearly in mind the fact that any malignant tumor may suddenly increase its rate of growth and consequent malignancy without any relation to the instituted mode of treatment. In a series of 20 cases of carcinoma of the rectum which is being prepared for publication *in extenso* by the senior writer the following observation was made. In the cases in which an attempt at a radical operation was made the condition recurred with greater rapidity and malignancy than in those cases in which

there was no operation done and only radium and Röntgen ray treatment given or an exploratory was done followed by radiations. Similar observations are surely made by any surgeon with a large cancer material. In this series of cases the malignant recrudescence of the disease was not caused by the operative interference, but accidentally took place after the operation. The same holds true of the recrudescences which occasionally may take place after radium or Röntgen ray treatment, thus pre- and post-operative radiations of cancer as a method of inhibiting the proliferating power and the consequent clinical malignancy of the tumor-cells is of undoubted value and presents no danger.

## CONSERVATION OF THE THYROID IN HYPERTHYROIDISM\*

By JOHN ROGERS, M.D.

OF NEW YORK

THIS is a plea for conservation rather than radical or destructive thyroid surgery. It is based upon operative experiences with 478 cases of thyroid abnormalities. Of these, 296 individuals presented the symptoms commonly accepted as those of hyperthyroidism, and were treated by the ligation of two or more thyroid vessels. In nearly every instance the operation was supplemented by organ feeding with preparations from some endocrine gland, generally the adrenal or the thyroid. Exophthalmos of one or both eyes was present in addition to the other evidences of hyperthyroidism in 169 individuals. These patients were treated by the ligation of all four of the chief thyroid vessels.

As the direct result of these 296 ligation operations there were 9 deaths, or a mortality of 3 per cent. One of these, apparently in good condition, on getting out of bed on the sixth day, died very suddenly from unknown causes; but the other eight perished from the usual "post-operative hyperthyroidism." It is decidedly worth noting that all of these fatal cases showed a more or less pronounced degree of exophthalmos, and all but three of the nine died after the ligation of one or two vessels. These six fatalities occurred early in my experience and followed attempts to check a more or less rapidly advancing hyperthyroidism. Evidently, as others have observed, it is not good judgment to interfere surgically during an exacerbation of this disease.

Of the 160 who recovered, the present condition of 128 has been ascertained: 102, or 70 per cent., can be safely called cured; 18, or 14 per cent., are "improved," and 8 are unimproved. Nearly all of the 26 who were not cured were poor hospital patients who could not long be kept under the all-important after-treatment of rest and organ therapy. So far as can be ascertained, none of the patients who have survived this quadruple ligation operation for hyperthyroidism have later suffered from any intensification of the disease or from myxoedema. Some relapses have occurred, but with very few exceptions they have been again "cured" by rest and organ therapy. One case relapsed several times after hard night work, and recovered several times, and finally lobectomy was performed, but I have lately heard she has again relapsed.

There is no doubt that in suitable cases perfect results can be obtained by excision of greater or less amounts of the thyroid gland, and it would be foolish to condemn that operation. But the statistics of partial thyroidectomy show about 20 per cent. or 25 per cent. of failures to cure hyper-

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\* Read before the New York Surgical Society, February 27, 1918.

thyroidism, in addition to a mortality which, even in the most experienced hands, is somewhere between 5 per cent. and 10 per cent.

In an attempt to improve upon these results, and as an aid in the selection of the cases, because partial thyroidectomy is essential for the cure of some, I have been guided by a hypothesis which assumes a close relationship in the causation and pathological physiology of all types of thyroid abnormalities. Clinically, these disorders seem interchangeable, and the same patient may at one period show the signs of hypo- and at another hyperthyroidism. Or one with a simple, which means an otherwise symptomless, goitre may later develop myxœdema or exophthalmic goitre. If, however, a sufficient number of individuals can be observed long enough, it is possible to trace more or less order in this confusion.

*The Apparent Course of Thyroid Abnormalities.*—Every kind of thyroid disorder seems to be preceded or accompanied by circumstances which manifestly or by inference involve the production and expenditure of energy and fatigue. There follows an enlargement of the gland, which is apparently an hypertrophy, to compensate for excessive demands upon the organ, or for demands which are greater than the organ of ordinary size can fulfil. From this first stage of simple (compensatory) hypertrophy, the condition may progress into (1) a quiescent "simple" goitre in which degeneration often takes place with the formation of cysts or tumors; or (2) into hypothyroidism and, with an intensification of these symptoms, into myxœdema, with or without atrophy of the goitre; or (3) into hypothyroidism of longer or shorter duration and then into hyperthyroidism, and finally into true exophthalmic goitre.

*Symptoms.*—The symptoms usually accepted as indicating hypo- or hyperfunctionation of the thyroid are, to a considerable extent, traceable to disturbances in the involuntary nervous system. This, it should be recalled, consists of two parts which, broadly speaking, seem to have somewhat opposing functions. One portion of this system is made up of a group of nerves sometimes called the "autonomic," which are in general stimulating or activating. These are the third, seventh, ninth, tenth and eleventh cranial nerves and the visceropelvic nerve. The other group consists of the cervical, thoracic and abdominal sympathetic nerves, which seem in general to inhibit or oppose the activating influence of the autonomic nerves. Every organ of the body, except, so far as is known, the brain, is supplied by a branch from each of these two groups of nerves, which thus appear to have much to do with coördinating the activities of the body.

The incipient first, or hypothyroid, stage of these disorders is marked by headache, dilated pupils, pallor, dry skin, a dry mouth, anorexia, gaseous indigestion and constipation, and a sense of weariness. The blood-pressure is regularly low. The diagnosis of hypothyroidism can only be established by the presence of a perceptible thyroid enlargement and a susceptibility to thyroid feeding. Without the "goitre," the condition is indistinguishable from general exhaustion or fatigue. Not infrequently these hypothyroid

patients complain bitterly of a sensation of compression or choking, or of actual pain in the region of the thyroid. This is relieved by rest and thyroid feeding, and intensified by nervous or physical effort. If the disturbance is to continue into the second, or hyperthyroid stage, the headaches and lassitude gradually disappear. The heart action becomes intermittently and then constantly rapid, and in the early stages often "thumps" or "pounds," and communicates its motion to the thorax. The eyes may show some lachrymation, and the mouth salivation. The skin is flushed and moist, the appetite is generally excessive and there is regularly more than one daily movement from the bowels. The nervous irritability and the tremor complete the picture ("vagotonic" type).

Later, or after weeks or months or years of hyperthyroidism, and in the mixed or irregular types of the disease, the flushed moist skin becomes pale or bronzed and dry, the overaction of the heart becomes merely a tachycardia, there is anorexia, gaseous indigestion and constipation ("sympathetecotonic" type). Exophthalmos may appear early or late or without any evidence of hyperthyroidism, and in recovery is generally the last symptom to subside.

It is generally agreed that the most positive evidence of hyperthyroidism is supplied by the calorimeter. But the means for applying this test are not readily available. An equally positive test is the histological examination of a section of the tissue which can be excised from the upper pole of the gland during the ligation of the superior vessels. If in a doubtful case this operation reveals no hyperthyroidism, no harm results.

When the symptoms are examined with reference to the involuntary nervous system, it will be noted that in the first or hypothyroid stage the involuntary nervous system gives no manifest signs except possibly that its autonomic or activating portion is inactive. During the early part of the next or hyperthyroid stage, the moist eyes and mouth, the flushed moist skin, the rather excessive appetite (gastric hunger contractions), the loose bowels, and the heaving rather than merely rapid heart action all point toward an excessive activity or activation of the autonomic or activating part of the involuntary nerves. Later in this stage, and in the irregular types of hyperthyroidism, the dry mouth and skin, the anorexia and constipation, and the commonly high blood-pressure and simple tachycardia all point toward a deficiency in the autonomic or activating nerves and a preponderance of impulses from the inhibitory or sympathetic system.

*Physiology.*—It has been quite definitely proved that the thyroid has much to do with the general process of oxidation. Hence the value of the calorimeter test in conditions of hyperthyroidism. The gland has also been proved by its effects upon the metamorphosis of the tadpole, and by clinical observations, to be of great importance in growth and development. There can be little doubt that it has some influence upon the functioning of almost every organ in the body, and this influence may be exerted through the involuntary nervous system. Extracts from the fresh pig thyroid gland have

been made under my direction with distilled water, with slightly alkaline normal salt solution and with alcohol. When tested upon dogs it has been found that the distilled water extract is inert, but that the alcoholic extract and the non-coagulable portion of the saline extract produce quite definite and immediate reactions. In brief, this material is vasodilating, it increases the vigor of both voluntary and involuntary muscular contractions, it is a stimulant to the secretory activity of the pancreas, and it increases gastric secretion and peristalsis. In the case of the stomach, this stimulant or activating influence can be prevented or arrested by the injection of either atropin, which paralyzes the terminal filaments of the vagus, or of adrenalin, which is believed to stimulate the sympathetic or opponent of the vagus.

In these experiments no material could be found which would produce any appreciable degree of tachycardia. Furthermore, no material could be isolated from the human pathological hyperthyroid glands removed at operation which would produce any reactions whatsoever. A few tests made with extracts from normal human glands, obtained at autopsy, acted with the same vigor as the pig extracts.<sup>1</sup> Hence, it looks as though the thyroid through its secretion activates or stimulates the autonomic or vagus group of nerves and not as is commonly believed the sympathetic. The hyperthyroid gland, on the other hand, seems inert. At least no material could be isolated from these pathological organs which would produce any reactions.

When these findings are compared with the symptoms of hyperthyroidism the results are rather suggestive. Apparently in the early part of this stage of the disease, as evidenced by the excessive activity of the autonomic nerves, there is a true superabundance of an approximately normal quality of thyroid secretion. This superabundance activates the autonomic group, and overpowers the opposing or inhibiting sympathetic, and thus, in part at least, causes the flushed and moist skin, the moist eyes and mouth, and the gastro-intestinal activity, and the heaving heart-beat (vagus stimulation?).

The cause of the tachycardia may thus not be the direct stimulation by the thyroid secretion of the cardia-accelerator nerve, but rather some response of the heart to the systemic needs for blood produced by the increased general metabolism.

As the disease continues, the evident excessive activity of the autonomic system disappears and is succeeded by an apparent excess or preponderance of sympathetic or inhibitory impulses.

It is legitimate, therefore, to infer that the thyroid first undergoes, in response to automatic impulses, a compensatory hypertrophy and then becomes fatigued and its secretion diminishes. A continuation of the fatigue in some way next impairs the quality but increases the quantity of the secretion, and hyperthyroidism appears. In course of time, the secretion gradually changes and becomes more or less inert. In the irregular types

<sup>1</sup> Amer. Journ. Physiol., vol. xxxvi, No. 2, Jan., 1915; vol. xxxvii, No. 3, June, 1915; vol. xxxix, No. 2, Dec., 1915; vol. xxxix, No. 3, Jan., 1916; vol. xl, No. 1, March, 1916.

of hyperthyroidism which from the outset have a preponderance of sympathetic nerve symptoms, the primary fault appears to be a poor quality of thyroid secretion. It is also worth noting that these atypical or "sympathetic" cases of hyperthyroidism are quite frequently benefited by thyroid feeding, while the "autonomic" group are always injured. Furthermore, the cases which do the best after the "radical" operation are always in the early or "autonomic" stage of the disease.

*Treatment.*—If the different thyroid disorders are related, as they seem to be, and run a more or less definite course which is regulated by fatigue, they should be prevented from progressing by thyroid feeding and by rest. That is, the common, simple hypertrophy which usually takes the form of a soft symmetrical enlargement of both lobes, should be regarded as compensatory to excessive demands upon a thyroid which in some instances at least may be congenitally weak. An enlargement of this kind should, of course, not be excised. The organism apparently needs more secretion than the thyroid of normal size can supply, and as fatigue intensifies and rest improves these conditions, thyroid feeding and mental and physical quietude should be instituted. If, however, the disturbance, even under the best of conditions, shows signs of advancing towards hyperthyroidism, surgery may become necessary.

As the impulses which cause the thyroid to hypertrophy and become fatigued and then overact are probably conveyed to the gland through the blood supply, it is logical to cut off some of the stimuli by ligating the vessels. It is not logical to resect the lobes. The decrease in the blood supply and the thyroid feeding by supplementing (?) the efforts of the gland can both be supposed to improve the functionation of the thyroid by affording it rest. When localized tumors develop, they presumably, at least, by pressure, interfere with the normal functionation of the adjoining healthy epithelium, and should therefore be excised or, more exactly, enucleated, in order to preserve as much as possible of the sound tissue. If, however, at any time the thyroid shows signs which indicate that it is compressing the trachea, it is, of course, necessary to remove enough of the gland to entirely relieve the pressure. This operation should also, as far as possible, be performed by the enucleation of cystic or adenomatous masses rather than by lobectomy. In addition to the obvious and often immediately dangerous mechanical interference with respiration in these cases, there may be some added difficulties (in the decreased air supply) which are connected with the oxidative function of the thyroid. At any rate, patients with goitres which compress the trachea seem prone to show symptoms of hyperthyroidism, and they cannot be relieved without at the same time relieving the tracheal stenosis.

After hyperthyroidism has become established, the cases can be classified for surgical treatment in two groups:

(1) Those in whom the removal of a greater or less amount of thyroid tissue, or lobectomy, offers the best outlook.

(2) Those in whom the ligation of all four (or fewer) of the thyroid vessels is preferable.

When there is a reasonable certainty that the disease is confined to one lobe or to a particular and recognizable portion of the gland, experience has abundantly proved that the removal of this abnormal part is very satisfactory. The recovery is usually prompt, and although a later recurrence or relapse is always possible, it is not probable. The localization of the diseased tissue, or of the histological changes which are characteristic of the hyperthyroid gland, apparently does not have to be exact or complete. As long as the major portion of the disease can be removed the prospects of cure seem good. This localization of the diseased process in one lobe or in one portion of the organ can be inferred from the comparative size and consistency and apparent vascularity of the different parts of the thyroid.

In my experience, the so-called radical operation, or excision of a greater or less amount of the gland, is liable to fail to cure, or to yield unsatisfactory results in the goitres which are symmetrically enlarged and of equal consistency and vascularity throughout. In these, every portion of the gland is probably involved, and the removal of one-half or more of the thyroid should leave the remainder as only less workable or less toxic than the entire organ. The *small*, symmetrically enlarged glands, accompanied by pronounced symptoms of hyperthyroidism, especially when the signs of sympathetic irritation preponderate and the blood-pressure is high, seem the most unfavorable for the radical operation of excision. On the other hand, the enucleation of a localized adenoma or cystadenoma in a gland which is causing hyperthyroid symptoms accompanied by high blood-pressure, has several times in my experience resulted in a most remarkable lowering of the arterial tension.

In all cases, therefore, in which the thyroid is symmetrically enlarged and of even consistency throughout or is presumably affected in all parts by the hyperthyroid changes, I advise the ligation of all four of the chief thyroid vessels. The operation should be performed under local and not general anæsthesia, and in two stages. The two lower arteries should be tied first, and it does not seem necessary to cut them. They are often large and rather deeply placed, and if the ligature slips, the difficulties in these nervous subjects may be considerable. During the recovery, there is an absence of the painful deglutition which always follows the ligation and division of the superior vessels. After the lower wound has healed, or a week later, the upper poles can be exposed through the usual transverse collar incision. The patient will then have shown some improvement and will better endure the subsequent discomfort. The inferior arteries are best exposed by a vertical three-inch incision along the lower end of the posterior border of the sternomastoid muscle. This generally crosses the external jugular vein, which will then have to be divided. The incision is deepened down to the outer border of the scalenus anticus. Then, mostly by blunt dissection, the loose cellular tissue in front of this muscle is sepa-



## CONSERVATION OF THE THYROID

rated, the great vessels with the vagus nerve are drawn forward and the inferior thyroid artery felt or seen to the inner side of the scalenus anticus. It can thus be readily tied between a double ligature and cut, although the division does not seem necessary.

After this quadruple ligation operation for hyperthyroidism there is usually an immediate subjective improvement, but the tachycardia may not subside for a long time, or for months. The calorimeter test also shows that the increased metabolism disappears with equal slowness. Nevertheless, this operation, as shown above, has yielded most satisfactory results, both as regards mortality and perfect and permanent cures. It needs, however, to be supplemented, like any other treatment for hyperthyroidism, by good hygiene and rest and by organ therapy. During recovery the disease retrogresses through a longer or shorter stage of apparent hypothyroidism and often much relief can then be afforded by the cautious administration of small amounts of thyroid material.

# MADDERIZED BONE AS A MATERIAL FOR BONE-GRAFTS

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(From the Department of Anatomy, Johns Hopkins University)

THE fate of bone transplanted into the osseous tissue of the same or another animal has long been a question of interest, but one not easy to decide, due to the difficulty of determining with certainty whether the material examined at some subsequent period was the original graft or new bone. Adopting the simple method of making the transplant absolutely recognizable months later by using well-stained madderized bone, and inserting it into the bone of an animal never fed madder, we were able to follow its subsequent history with ease.

The advantage possessed by madderized bone as graft material consists in the fact that its bright red color stands in sharp contrast to normal bone. The coloring agents which it contains, alizarin and purpurin, are united closely with the ordinary bone salts (Gottlieb,<sup>1</sup> Macklin<sup>2</sup>), so that madderized bone is not decolorized during the course of the animal's existence except as the bone salts themselves are removed. Furthermore, the bone stained in this way is absolutely non-toxic, and behaves exactly like normal unstained bone; like it being torn down in the course of osseous catabolism incident to development and to the wear and tear of ordinary life. These facts are quite apparent from the madder literature. Thus, madderized bone is simply ordinary living bone which is stained characteristically and permanently.

In order that the graft may be readily recognized, the madder staining should be intense and present throughout the bone. To satisfy these requirements the animal from which the insert is to be taken should be fed madder daily from a very early period of life, preferably from birth (Macklin<sup>3</sup>), and the feeding continued up to the time that the bone is removed. If the feeding is not begun early enough some of the original bone will remain unreplaced by madderized bone, and if madder feeding is discontinued for an interval before the graft material is used there will be new unstained bone deposited over the stained part. In either case the unstained bone of the graft would lead later to confusion with new bone deposited subsequent to transplantation.

Allowance must be made for variation in rate of absorption due to the age of the grafted animal. In a very young animal the bone resorption and growth is rapid, so that the transplant is soon absorbed and replaced with new bone in the normal processes of the animal's growth, whereas in an

older animal the resorption process is slower. This method is easily adaptable to a comparative study of resorption rates of grafts in animals of various ages.

It is essential, of course, that an animal be chosen which eats the dye-stuff readily. Not all animals do this, cats showing a marked aversion to the ground root, and dogs refusing it unless thoroughly mixed with meat. Rats, however, take the dye-stuff readily when intimately mixed with their ordinary food.

For the brief preliminary work here recorded rats were used, which were obtained from the excellent colony of the Wistar Institute, Philadelphia, where the experiments were conducted. Only transplantation into the flat bones of the skull was done. Specimens were examined in the fresh condition, after being cleared in oil of wintergreen by the method of Spalteholz<sup>4</sup> and after being sectioned.

The operations were conducted as follows: A trephine opening, 5 mm. in diameter, was cut through the parietal area of the unstained animal, and into this was placed a piece of bone obtained in a similar manner a few minutes before from an animal which had been fed madder for a period so long that the entire bone was stained. The wound was then closed, and the animal kept on the ordinary diet of table scrap till death. Two animals were thus treated. One was sacrificed fifty-one days after operation; the second after five months.

In both cases the skull showed the madder transplants still in place. In the cleared specimens the picture is most striking, the bright red insert standing out in sharp contrast to the colorless surrounding area. It is easy to see that the insert has been revascularized and apparently permanently welded into place in the skull by unstained callus. There has been some bone erosion at the edges of the insert, as well as at the outer edges of the opening in the skull of the grafted animal. In places in the graft, too, the red bone has been replaced by new uncolored bone, so that some wearing away of the transplant has occurred. It is noteworthy, however, that so much of it remains, even at the end of five months.

Much of the material resorbed was doubtless bone injured by the trauma, and it may be that aside from this the erosive processes occurring in the graft were merely those common to the skull as a whole, in the course of everyday metabolism. Indeed, these findings suggest that the foreign bone has not merely served as a framework on which osteoblasts might erect a totally new structure, it itself being resorbed simultaneously with the laying-down of the new bone, but that it has actually become incorporated into the living bone about it, and will undergo resorption only as this process is carried out on the rest of the skull with the normal metabolic processes.

While the observations here recorded are limited, we believe the method contains possibilities which will make it of value in tracing the fate not only of living bone grafts, but also of dead ones, for madderized bone of the type described can easily be killed by boiling, and then inserted. Although the

long bones of the rat are rather too small to be conveniently handled as bone grafts, those of a larger animal, such as the pig, could be easily employed in this way.

There is one disadvantage in this method. The process of decalcification brings about an almost complete decolorization of the bone on account of the fact that the principal dye-stuff of madder, alizarin, loses its color in an acid medium. Gottlieb<sup>1</sup> asserts that a little of the staining remains after immersion in the acid, and we have found that this is true with intensely stained bones, but the coloration is so faint as to be indistinguishable in sections of ordinary thickness. However, the finer details may be studied in sawn and polished sections, or in thin slabs of bone cleared by the method of Spalteholz.

The converse of this course may also be followed; after an unstained graft has been transplanted into the bone of an unstained adult animal the latter is put upon a madder diet until killed, with the result that all the new bone subsequently deposited is colored red. Thus, if the graft be substituted by new bone it would be possible to observe the rapidity of its displacement by noting the progressive increase of new red bone in a series of cases.

Any new bone laid down in the course of metabolism would also be colored, and by comparing the amount of this with the amount of bone replacing the graft it would be possible to say whether or not the deposition of new bone in the graft exceeded that in other areas of the body, and thus whether the graft was being substituted in the course of normal osseous catabolism or by a special erosive process.

NOTE.—Our attention has been called to a somewhat similar method of bone staining used by Barney Brooks and reported in the June, 1917, and December, 1917, numbers of this Journal (vol. lxv, p. 704, and vol. lxvi, p. 625). These articles were unknown to us at the time of writing. Our work was done in the summer of 1916, at the Wistar Institute, Philadelphia, and the specimens were demonstrated at the meeting of the American Association of Anatomists in New York, December 28, 1916.—M. D. T. and C. C. M.

#### LITERATURE

<sup>1</sup> Gottlieb: *Anat. Anz.*, 1914, xlv, 179.

<sup>2</sup> Macklin: *Jour. Med. Res.*, 1917, xxxvi, 493.

<sup>3</sup> Macklin: *Anat. Rec.*, 1917, xi, 387.

<sup>4</sup> Spalteholz, W.: *Über das Durchsichtigmachen von menschlichen und tierischen Präparaten und seine theoretischen Bedingungen*. Ed. 2, Leipzig, 1914.

## THE USE OF SMALL BONE TRANSPLANTS IN BRIDGING A BONE DEFECT

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IN certain types of fractures of one of the bones of the forearm where there is malunion with loss of substance it is frequently difficult to properly brace the resulting defect. The bone is too small to maintain a transplant in position by the use of a Lane plate or other device; and the insertion of an intramedullary splint with a dowel is a procedure of considerable difficulty and requires a large exposure of the fractured bone. In performing bone transplant operations in dogs while pursuing the study of bone repair the writer was struck with the universally good results obtained by transplanting small bone fragments, 1-2 mm. in size, to fill a defect in the shaft of the radius. Although this study is purely an experimental one, it is reasonable to assume from the results obtained that it will be of distinct clinical value in well selected cases.

*Description of a Typical Animal Experiment.*—Under ether anæsthesia the radius is exposed for a distance of at least 4 cm., the surrounding structures are dissected free from the shaft and a portion of the shaft about 3 cm. long is removed. The periosteum is excised for a distance of 1-2 cm. from both cut ends of the radius. The excised piece is now freed of its periosteum, it is split lengthwise and all visible endosteum is removed. Following this it is cut into small fragments 1-2 mm. in size, and these little fragments are inserted into the bone defect (see Fig. 1). The muscle, fascia, and skin are closed in layers; a gauze dressing followed by a plaster-of-Paris bandage is applied.

At regular intervals following operation radiographs have been taken and the dogs sacrificed. The leg is then examined clinically and later decalcified and sections are made for microscopic examination.

*Results.*—Twenty-six dogs have been operated upon in the manner described above, of these two have become infected, two fractured the radius by jumping off elevations and angular union occurred. Of the remaining twenty-two good union has occurred in almost every case. This is remarkable, as it is impossible to immobilize the foreleg satisfactorily and the dogs use them from the very first day post-operative. The gross examination in the early stage reveals numerous irregularities of the bone; as time progresses, however, the rough areas are absorbed and the bone resumes its normal form. It is interesting to note that whenever a tendon is in close proximity to these fragments it eventually forms a depression such as normally occurs in the bicipital groove. In specimens one year after operation it is often difficult to find the location of the transplants.

*Radiographic Findings.*—In studying a series at intervals after operation it is seen that the transplants become gradually smaller while about them a formation of new bone occurs. At later stages the form and contour of the shaft is re-established. In two

instances where there has been clinical union a transverse line has been observed by X-ray (Figs. 12, 13, 14 and 15).

Microscopical sections taken from seven days to one and one-half years show that there are two main factors involved in the repair of these bone defects: Namely, first, the bone fragments, second, the organization of connective tissue about the fragments. Let us consider these two factors separately.

1. *The Transplanted Bone Fragments.*—In from ten to twenty days after operation the bone cells in the central portions of the fragments lose their standing reaction, while those at the periphery are still viable.

Immediately following transplantation clotted blood is seen in the Haversian canals with fibrin formation. In about four weeks blood-vessels containing normal appearing blood-cells are seen. It is difficult to determine whether the blood is re-established through the old vessels or new ones are formed. About these larger canals there appear two or three concentric layers of bone cells with normal staining nuclei. At the periphery of the fragments areas of rarefaction and areas of new bone formation occur (Fig. 7).

2. *The Connective Tissue About the Fragments.*—After the operation blood clot forms about the fragments, gluing them together; it becomes organized by granulation tissue; fibroblasts are seen growing in from the periphery and then young blood-vessels appear. As the granulation tissue becomes organized calcium salts are deposited in the perivascular areas forming a very definite new bone. A very low power microscopical picture of this connective tissue at this stage appears similar in design to an irregular lace curtain pattern, the dark staining areas which correspond to the web of the curtain consist of new bone, while the light staining areas are composed of blood-vessels and young connective tissue (Figs. 9 and 10).

At a later period these new bone areas increase in size at the expense of the young connective tissue, the latter gradually changing into fibrous connective tissue. Sections under high power show gradual graduations of the cellular elements; from connective tissue to bone, from connective tissue to fibrocartilage, and from fibrocartilage to bone.

As time progresses the bone fragments are gradually absorbed and lose their identity in the mass of new bone forming from connective tissue. In a year the medullary canal has been re-established and we have tubular bone which is difficult to distinguish from the normal shaft. The Haversian canals have reformed in the direction of the long axis of the shaft. The bone is covered with a connective tissue layer resembling periosteum (Fig. 5).

In the two or three cases where the X-ray showed an artificial joint we find that the adjacent bone surfaces are covered with cartilage and an adventitious joint has been formed (Fig. 4).

Too much importance has been placed by most authors upon the origin of the bone cell as the vital factor in bone repair. This has clouded our conception of the process. Bone is mesoblastic in origin, and in its repair we find that calcium salts are deposited on the intracellular elements of connec-

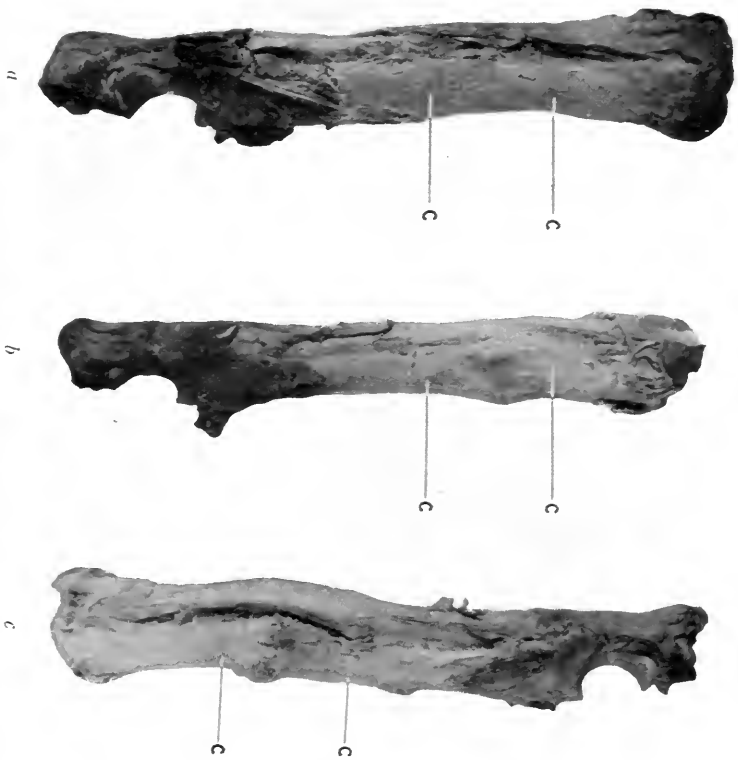


FIG. 1.—Showing how radial transplants have fused. *a*, bone defect filled with transplants, *a*, duration, 332 days; *b*, duration, 163 days; *c*, duration, 271 days.

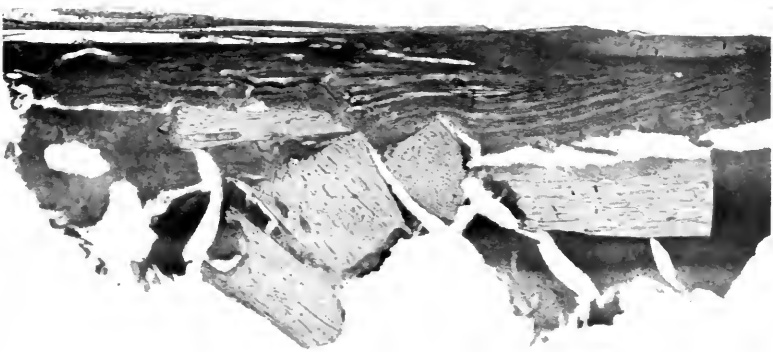


FIG. 2.—Duration, 4 days. Appearance of fragments soon after transplantation. They are surrounded by blood-clot.



FIG. 3.—Longitudinal microscopical section (low power). Duration, 46 days. *a*, ulna; *b*, radius; *cc*, fragments in radial defect. Rarefaction of fragments with new bone formation about them.

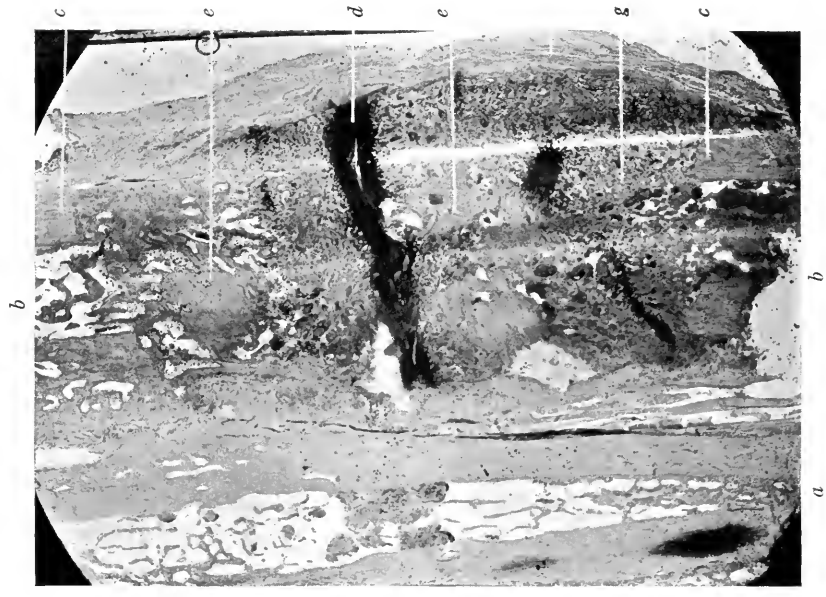


FIG. 4.—Longitudinal microscopical section of radius and ulna. Duration, 141 days. *a*, ulna; *b*, radius; *cc*, cut ends of radius with bone fragments between; *d*, cartilage forming false joint; *e*, bone fragment—nuclei do not stain—areas of rarefaction seen near periphery; *f*, fibrous tissue capsule continuous with perosteum; *g*, new bone formation about periphery of fragments.



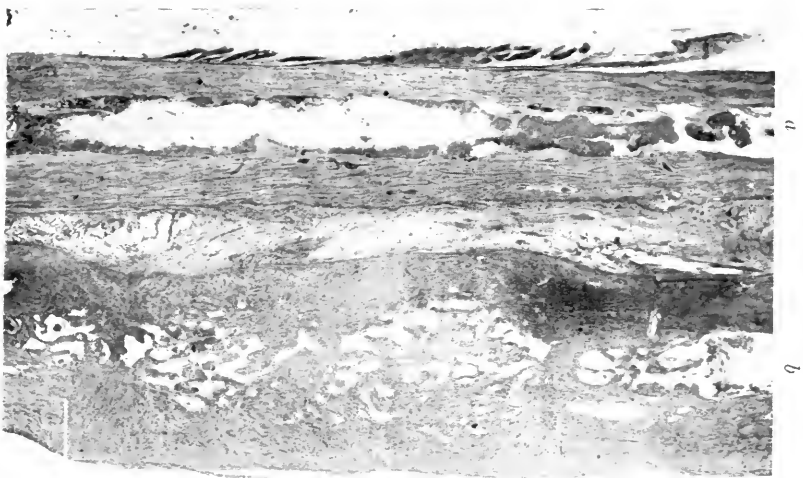


FIG. 5.—Longitudinal section. Duration, 347 days. *a*, where *b* radii; *c*, boundaries of transplanted fragments. Medullary cavity is being reformed. Tendency of Haversian canals to run in long axis of shaft.



FIG. 6.—Duration, 370 days. Good union; fragments have disappeared. *aa*, area of transplants.



FIG. 7.—High power of portion of transplanted fragment; *a*, fragment—nuclei of bone cells do not stain; *b*, new bone formation about the periphery of the fragment—nuclei show normal stains; *c*, blood vessels in Haversian canals—blood-cells show normal staining reaction—two or three layers of normal appearing bone-cells about blood-vessels.

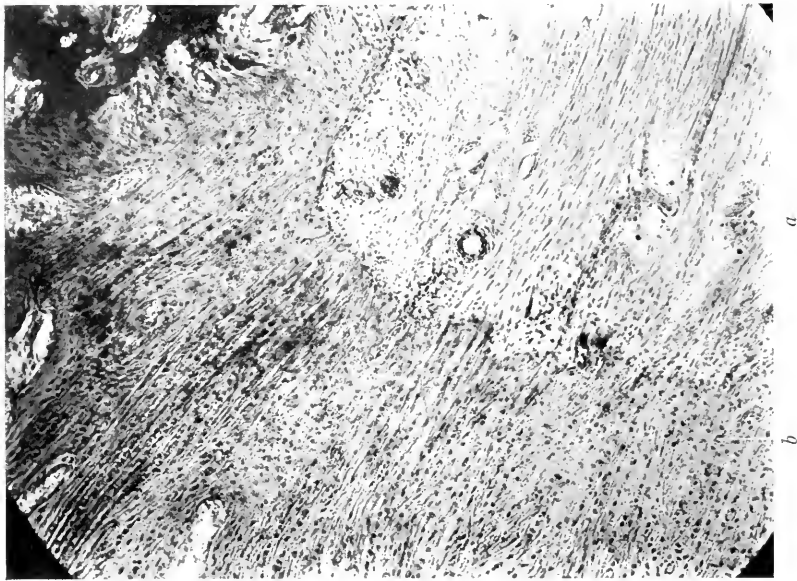


FIG. 8.—High power, showing junction of connective tissue and bone. Collagen fibres seen extending into the bone. Cells are of same character in bone and connective tissue, but the chemistry of the intercellular substance has changed. *a*, connective tissue; *b*, bone.

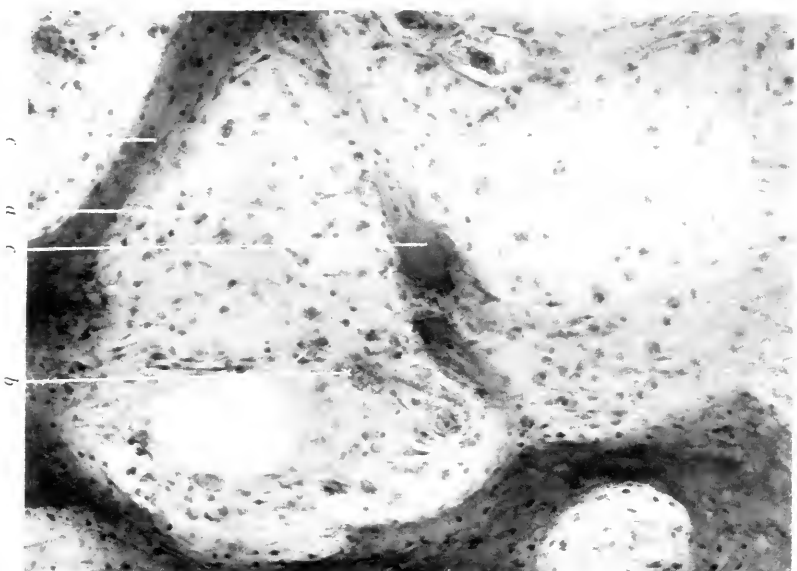


FIG. 9.—High power view of new bone formation. Duration, 12 days. *a*, granulation tissue; *b*, blood-vessels; *c*, new bone—the gradations of the intercellular substance can be plainly seen; there is no specific bone-cell, but a gradation of connective-tissue cell with calcium deposited as bone about it.

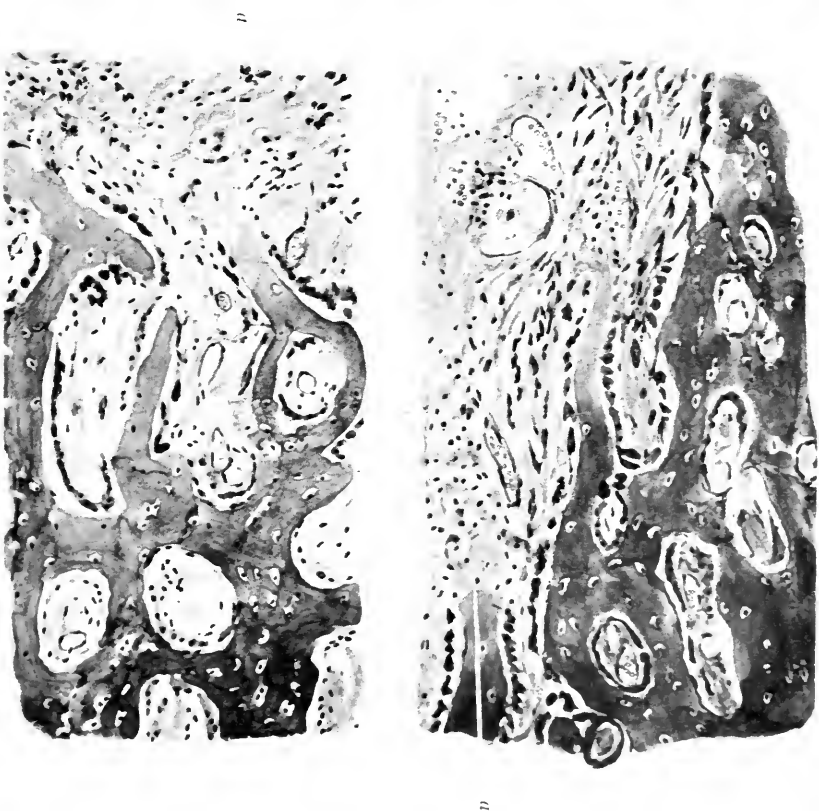


FIG. 10.—High power of bone of involucrum in case of osteomyelitis. Duration, 2 months. At *a* may be seen the gradual fading off of the bone matrix into the collagen fibres. The gradual transformation of a fibroblast to a bone-cell is seen. (Courtesy of Dr. William Clarke.)

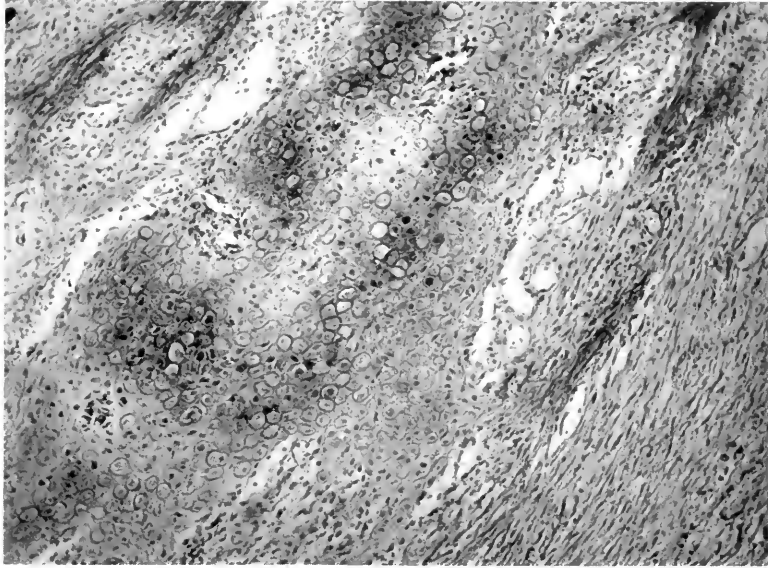


FIG. 11.—High power of fracture of humerus. Duration, 11 days. Transformation of connective tissue into cartilage. (Courtesy of Dr. Allen O. Whipple.)

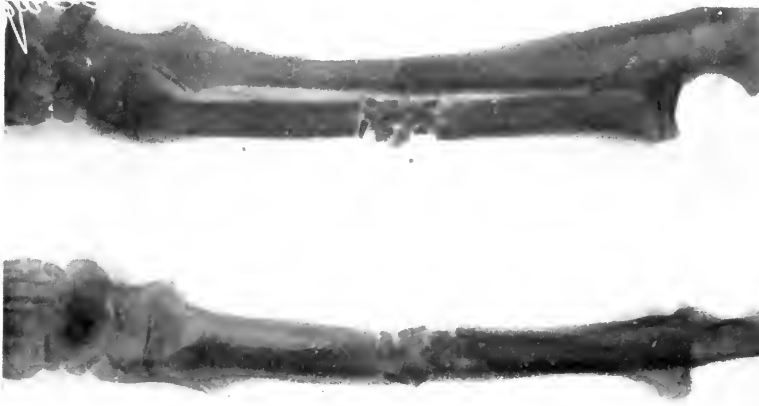


FIG. 12.—X-ray shows bone fragments filling defect. Duration, 13 days.

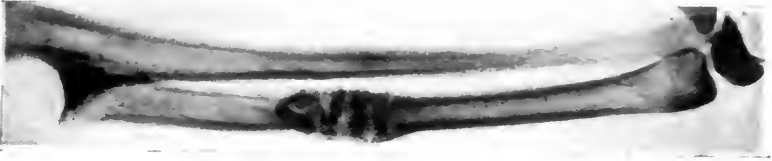


FIG. 13.—X-ray shows bone hypertrophy with union of fragments. Duration, 141 days.

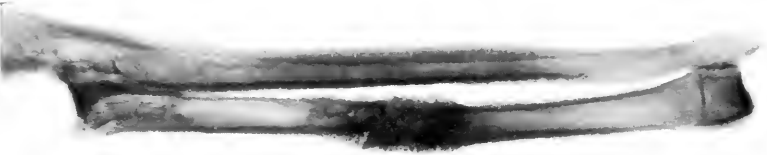


FIG. 14.—Duration, 134 days. Fragments have united—no cross union between radius and ulna.



FIG. 15.—Duration, 370 days. Contour of bone is approaching the normal; individual fragments no longer detected by X-ray.



## THE USE OF SMALL BONE TRANSPLANTS

tive tissue forming new bone. The connective tissue cell then, by a process of metaplasia, becomes a bone cell. Periosteum is a connective tissue and hence is prone to form bone, but it is not the only connective tissue that has this function. If this theory is assumed, it will explain the extra-skeleton formation of bone as in arteries, myositis ossificans, ovaries, kidneys, etc. (Figs. 9, 10, and 11).

Neuhof, working in the experimental Research Laboratory of Columbia, found bone constantly present in fascia lata and fat transplants in the bladder and occasionally in the stomach.

In the operative treatment of comminuted depressed fractures of the skull surgeons have been accustomed to leave the fragments in place, the fragments unite and prevent the brain hernias that occurred before this procedure was adopted. Finney, at Johns Hopkins, has used this method in ununited fractures of long bones.

In the experiments described above the periosteum was removed from the fragments in order to observe if such fragments would live; clinically it would seem advisable to leave the periosteum attached, as it is plausible to assume that the blood supply will be more quickly supplied to the fragments through the medium of the periosteum.

From the clinical point of view this procedure offers an adequate method of bridging a bone defect if there is another bone present to act as a splint and if it is possible to hold the bones in adequate position by external support. It offers the advantage of not having to expose a very large area and of not having to introduce a foreign body.

No originality is claimed for this method, as bone fragments have often been used to fill bone cavities. McEwen, in his work, reports bone growth from bone fragments.

I wish to express my thanks to Dr. William C. Clarke, of Columbia University, for invaluable advice and for the privilege of performing these experiments in the Surgical Research Laboratory of Columbia University.

## NOTE ON ISOLATED ABSCESES OF LONG BONES

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THE incidence of isolated bone abscess as a part of osteomyelitis has received scant attention, and has been followed by few reported cases. Any discussion, then, concerning diagnosis may fix the attention more firmly in the minds of physicians when obscure bone lesions are being considered.

I wish to review, briefly, its symptoms, and call attention to the ease in diagnosis when present and certainty of its cure. Probably like many other simple but rare processes, it escapes detection because we do not think of it in differential diagnosis.

The history is indeed suggestive—it is always a chronic thing—the Röntgen plate is practically always diagnostic, and its cure both rapid and certain when treated by standard surgical principles governing bone lesions.

The type I have especially in mind is the closed form in which a tell-tale sinus does not communicate with the skin to give proof of deeper bone destruction. The deeply seated pain, its continuance, and, above all, muscle spasm involving the region of a joint make the diagnosis of rheumatism a very likely one. The occurrence of increased pain associated with barometric changes may seem to justify such a conclusion. Therapy calculated to relieve the angina of rheumatism is entirely without benefit; indeed, opiates are highly unsatisfactory. Nocturnal pain was a marked characteristic of the reported case.

Mrs. S., aged twenty-eight years, foreign born, had an infection in right os calcis when a child. The wound discharged four months, when a small piece of bone came away. It then promptly closed. In about two months some soreness was noticed near the point of right deltoid attachment. This soon quieted. For the past five years she has had soreness and discomfort in the right arm; this coming on fifteen years later than the primary trouble. Symptoms have increased in severity, especially marked in stormy weather and at night. Muscle spasm fixed the arm at about  $15^{\circ}$  in the extended position. During the period of observation she never carried more than one degree of fever.

The likelihood of error is reduced to practically nothing if the suspected bone or joint is subjected to an X-ray examination and the plate properly interpreted. In brief, the findings are characterized by a dense eburnated area surrounding a translucent spot—the abscess cavity. In the long standing cases, and this is definitely a chronic process, this dense bony infiltration shows nature's response to local stimulation, the medullary cavity having disappeared as such. This fusiform bony tumor differs entirely from other lesions which might be confounded with it; *e.g.*, the absence of bony deposit





FIG. 1.—Pusiform tumor. No medullary cavity. Light area is abscess.



FIG. 2.—Showing opening in bone three days after operation.



FIG. 3.—Seven months after operation. Operative defect almost repaired. Evidence of a medullary canal.



on the convexity, as in syphilis, or the thickening on its concavity, as in rickets.

That the process is essentially one of destructive osteomyelitis is proved by the similar and constant bacterial findings in those cases where cultures have been made. It is a staphylococcus lesion, and unless secondary to a local injury, hæmatogenous in origin. The report of Dr. E. G. C. Williams of Lake View Diagnostic Laboratory was staphylococcus albus.

That its cure is surgical, and in no way affected by other than surgical measures, seems proved by rapid healing and absence of pre-operative symptoms following drainage. The principal complaint—pain—is likely due to tension within the closed bony cavity. A drill opening releases the pus with a spurt. It continues to flow till pressure has been equalized. In a typical abscess occupying the shaft, surrounded by eburnated bone, no sequestrum is present. A medullary abscess extending along the interior is quite another process and may be associated with a sequestrum.

In all reported cases the rational surgical procedure—drainage—seems to give perfectly satisfactory results. The primary drill hole must be enlarged to the periphery of the cavity, leaving a cup-like depression in the bone. Curettement shows little if any pyogenic membrane, the abscess wall being sharply defined. Simple gauze drainage of the soft parts is sufficient, an organized clot filling the bone cavity.

## NITROUS OXIDE, OXYGEN, ANÆSTHOL SEQUENCE IN ORAL SURGERY

BY CHARLES H. SANFORD, M.D.

OF NEW YORK

ATTENDING ANÆSTHETIST TO THE GERMAN HOSPITAL

It has occurred to me for the past few years that the oral operator has not always received the best kind of an anæsthesia for his patient, nor has due consideration been given the method of anæsthesia administered to patients about to have their tonsils and adenoids removed. Whether it is because this operation is so common and the patients usually uncomplaining and unsuspecting children, I do not know, but it is my belief that the patient requiring this operation is entitled to as much consideration on the part of the anæsthetist as is given the patient undergoing any major operation.

To saturate a child or older patient so deeply with ether that he remains under the influence of it long after the completion of the operation is to my mind unnecessary and harmful and therefore bad practice. This method, with its resultant gagging and strangulation, is quite faulty, it is against the well established rule of administering just enough anæsthetic as the case in hand requires, and is unscientific in this age when we are endeavoring to measure accurately the quantities and proportions of our anæsthetic mixtures and sequences. Furthermore, it has a tendency to hurry and disconcert the operator, and is responsible, I dare say, for many an uvula that has come out and part of many a tonsil that has remained behind.

It has, therefore, been my endeavor to administer an anæsthetic which was least depressing to the patient, which could be nicely controlled, and which permitted of uninterrupted and careful work in the oral cavity especially, and about the head generally. I am free to admit that this form of anæsthesia was made possible by the perfection during the past few years of many new apparatuses and devices for the administration of warmed gases and vapors which are far less irritating to the mucous membranes than the cold, unvolatilized anæsthetics. This fact should not be disregarded, for, with better equipment at our disposal, better and smoother anæsthesias should be our aim.

For work in and about the mouth, the nasal passages are convenient channels through which to pass the vapors and gases, while the pharynx, through means of endopharyngeal tubes, serves admirably for work on the nose and upper part of the head. The nasal passages, however, are quite sensitive and will not permit of the passage of strong ether vapor in quantities which are necessary, even in children, when the mouth is wide open, since this permits of great dilution of the vapor in the pharynx. With quantities of ether sufficient to keep the patient under by this means, salivation and strangulation occur as in the open administration, even to a con-

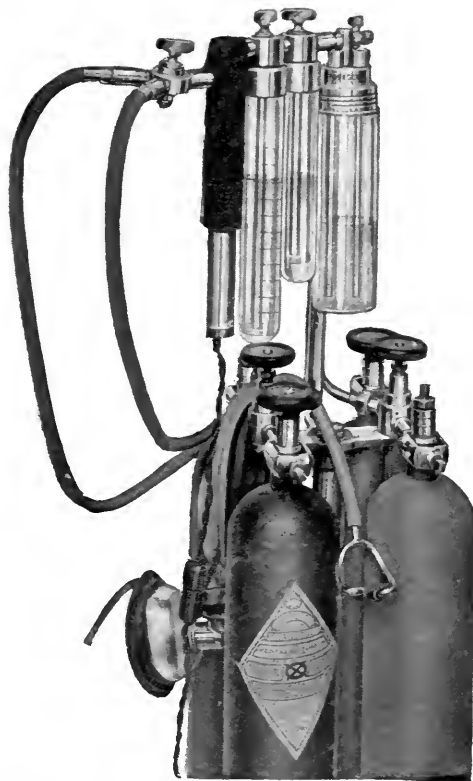


FIG. 1.—Photograph showing two bottles, heater, two-way valve attachment with surgical inhaler and special self-retaining nasal tip. Anæsthol in small bottle, ether in large one.

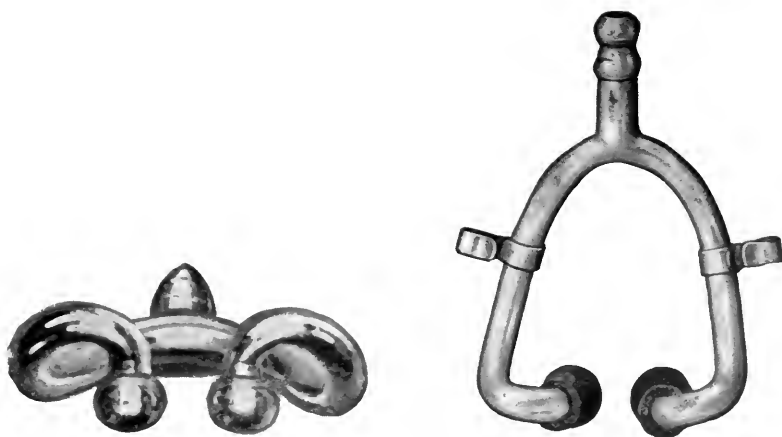


FIG. 2.



siderable degree when the vapor is warmed. Chloroform I have found unsatisfactory for use in children during tonsil and adenoid extraction, because great distress follows the temporary shutting off of respiration when the tongue is depressed.

*Anæsthol*, which is a mixture holding in stable chemical union 17 per cent. of ethyl chloride, 35.89 per cent. of chloroform and 47.10 per cent. of ether, seemed better suited. On account of the ethyl chloride it is quite rapid in its action, and its ether content is sufficient in stimulating qualities to offset the depressing effect of the chloroform in it.

*Apparatus*.—The apparatus which I have used is the latest type Gwathmey, with water sight feed, so that the proportions of gases and vapors used will be in terms of the gases bubbling through a number of holes. It is fitted with two bottles, one containing ether, the other anæsthol. At the end of the electric heater I have placed a by-pass for convenience in switching from the surgical inhaler and nitrous oxide, oxygen, ether to the nasal tip and nitrous oxide, oxygen and anæsthol (Fig. 1).

*Technic*.—The induction of anæsthesia has varied somewhat with the case and the individual, selecting the anæsthetic for induction according to physical conditions, temperament, age and sex. Accordingly, I have used anæsthol on a mask, then switched to the nasal tip and nitrous oxide, oxygen and anæsthol for the remainder of the operation as I shall describe later. When I use the surgical inhaler I induce with nitrous oxide, oxygen and ether as follows: The patient is rendered unconscious by nitrous oxide and oxygen alone until the characteristic stertorous breathing sets in. Then a very short jet of ether vapor is sprayed into the mixture by turning on the ether valve for a second only. This is repeated at short intervals until the patient receives the constant flow of the ether vapor without exciting a cough. When the respiration has become free and quiet, I switch over to a special nasal tip which I have recently devised (Fig. 2) and insert it into the nares, having first adjusted it before starting anæsthesia.

I now regulate the flow of oxygen and nitrous oxide to two holes in each sight feed, about 33 per cent. of oxygen and 66 per cent. of nitrous oxide, and begin the constant flow of the anæsthol vapor by very slightly turning on the valve on top of the anæsthol chamber. In a few moments you will know whether your patient is coming out or going under more deeply and regulate the flow of the gases through the anæsthol accordingly. I have seldom found it necessary to whip the anæsthol into a foam for more than a few seconds while finding or changing the plane of anæsthesia, but have kept it going in distinct bubbles.

At this rate, most patients will be carried through the operation. But I have found it convenient when desiring a deeper plane of anæsthesia to add not more anæsthol vapor per se, but more nitrous oxide, which then automatically increases the vapor proportionately. In this manner I have recently conducted an entire anæsthesia for resection of the lower jaw lasting two and one-half hours, with only an occasional slight turn of the nitrous oxide

valve. In the manner just described I have given numerous anæsthesias for dental work lasting over an hour, without interrupting the operation, without causing salivation, and with very rapid return of consciousness after stopping the anæsthesia. In some cases I was able to induce with the nasal tip, in which cases it was necessary merely to cup the hand over the mouth, induction taking about seven minutes. There is no direct advantage in this, however, it simply shows that this sequence—nitrous oxide, oxygen and anæsthoh—is practically non-irritating. In children over seven years of age, I have almost regularly used this sequence after inducing with the surgical inhaler and ether, or using anæsthoh on the open mask, and then switching to the nasal tip and anæsthoh when the mouth gag is inserted.

The quantity of anæsthoh used varies considerably with the nature of the operation, its duration and the age and sex of the patient. In the jaw resection mentioned above I used one ounce per hour during the two and one-half hours of anæsthesia, the patient, a rather slender and frail woman of fifty, fully recovering consciousness in three-quarters of an hour. For the removal of seven impacted molars, an operation lasting one and one-quarter hours, I used twenty cubic centimetres. For tonsil and adenoid cases I rarely use over fifteen cubic centimetres. The average mastoid case requires between twenty and twenty-five cubic centimetres. It will be seen from these few examples that the amount of anæsthoh used is comparatively small as compared with the open method, and the advantages in regard to comfort for the operator, effect upon the patient, ease of administration, and rapid recovery without, in many instances, any nausea or vomiting, would seem to me enough in its favor to warrant its use. There has not been a single instance where I felt at all uneasy during its administration; there have been no untoward symptoms.



## RECTUS MUSCLE TRANSPOSITION IN CERTAIN CASES OF INGUINAL HERNIA\*

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SINCE the declaration of war and the operation of the draft and troop mobilization, larger numbers than usual of hernia cases have appeared. Those from whom strenuous work will be expected and who need the greatest security we can give them for their own sake and that of the nation. For this reason I have been prompted to bring the subject before you again and for discussion. While the percentage of hernial recurrence is small in those going back to ordinary avocations, we have occasionally to deal, as at present, with many going to avocations of extraordinary *physical* requirement.

In, I think, the common experience, the recurrences which take place are usually of the direct variety, through the inner half of the posterior wall of the inguinal canal. The very simple procedure of rectus transposition followed by the usual internal oblique suture of Bassini superimposed doubly insures this area where muscle is thinnest and often deficient and transversalis fascia frequently stretched and attenuated as well. It is far from every case that needs any embellishment of the classic operation, and rectus transposition in no way takes the place of Bassini's procedure, but is to be done in conjunction with it in that smaller number of cases who present well marked muscular and aponeurotic deficiencies of the inner half of the covering of Hesselbach's triangle.

From time to time patients present themselves with the inguinal variety of hernia and where the internal oblique muscle is so deficient and transversalis fascia so thin that when the external oblique aponeurosis is divided three or four fingers can be pushed into the abdomen invaginating peritoneal tissue. Many cases with good sized herniæ and weak posterior wall gave nevertheless good muscle for repair without additions. It is those who have not that we are concerned with, about six to eight per cent.

In 1913<sup>1</sup> I traced the history from 1890, the year of Bassini's original communication, of the attempt by various operators to fortify this area. The earlier methods were complicated and gave about five per cent. of recurrences; those of the last ten years much simpler. The suture of an atrophic

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\* Read before the New York Surgical Society, January 23, 1918.

<sup>1</sup> ANNALS OF SURGERY, October, 1913.

internal oblique *together with* the inner half of the external oblique aponeurosis to Poupart's ligament seems to have much to commend it in simplicity, but living muscle has always proven a more permanent barrier against hernia protrusion. The procedure which seems more adequate yet hardly adds ten minutes to the operation, rectus transposition, I have followed for the last six years in nearly sixty cases where it has seemed necessary.

Retraction upward of the oblique muscle and aponeurosis exposes the rectus covering. Incising this for three and one-half inches behind the oblique aponeurosis and down to the pubes allows the rectus to be brought out without tension after the finger frees the muscle from its light attachment to

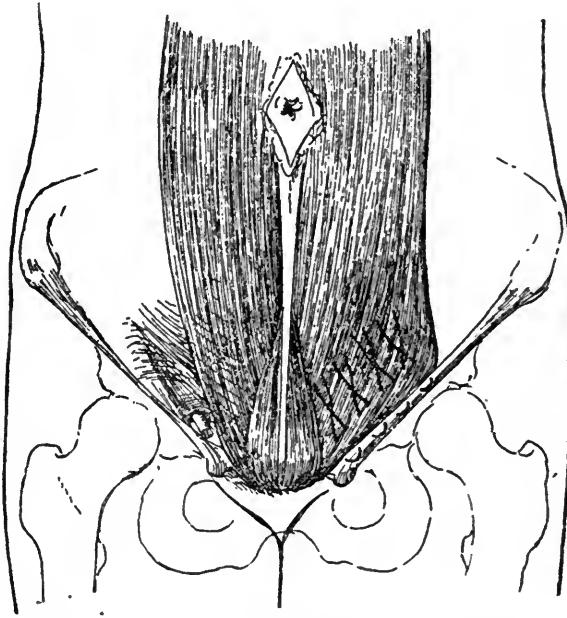


FIG. 5.—Deviation of fibres of rectus (after Bloodgood).

the sheath. Four kangaroo sutures of medium size attach it to the lowermost shelving portion of Poupart's ligament. The cord is transplanted as usual and the internal oblique and its aponeurosis sutured down over the rectus following the routine method. The external oblique aponeurosis is closed edge to edge or overlapped, depending upon its normal tension or redundancy. I would like to emphasize *the freer opening of the rectus sheath down to the pubes together with the separation of the muscle from its light attachments to the sheath* as a very great aid and sometimes necessity for the apposition to Poupart's without tension. The deviation of the muscular fibres is but little in this way and four sutures distribute what tension there may be. The lowermost stitch should leave no opening between the rectus and Poupart's liga-

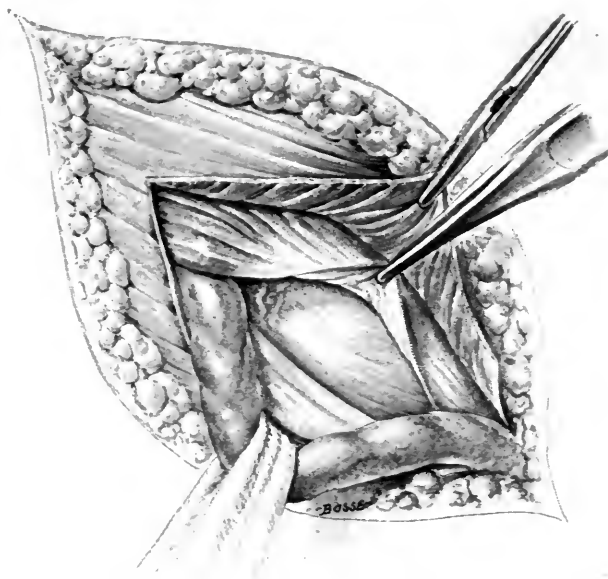


FIG. 1.—External oblique aponeurosis divided. Internal oblique muscle and aponeurosis retracted.

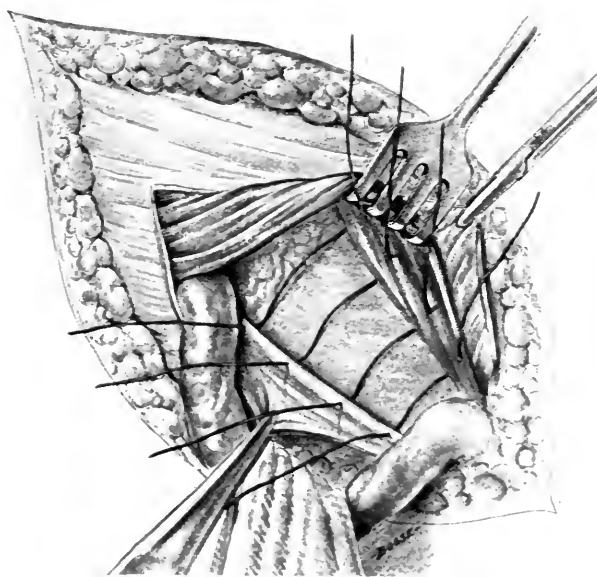


FIG. 2.—Rectus sheath opened, and, muscle having been freed, sutures are taken through muscle.

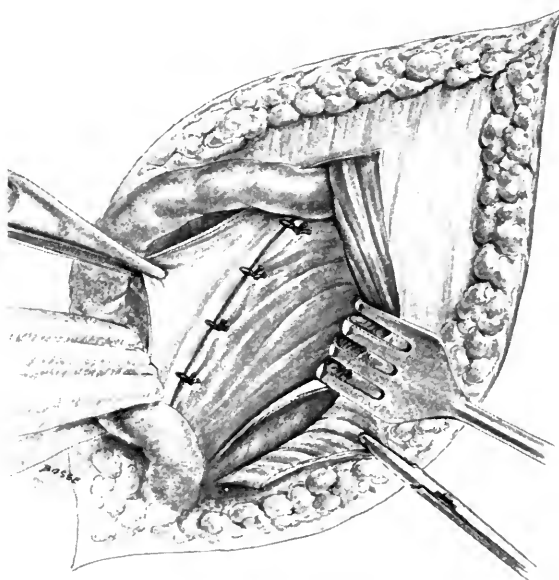


FIG. 3.—Rectus drawn to Poupart's (lower stitch should be taken nearer pubes, leaving no opening whatever).

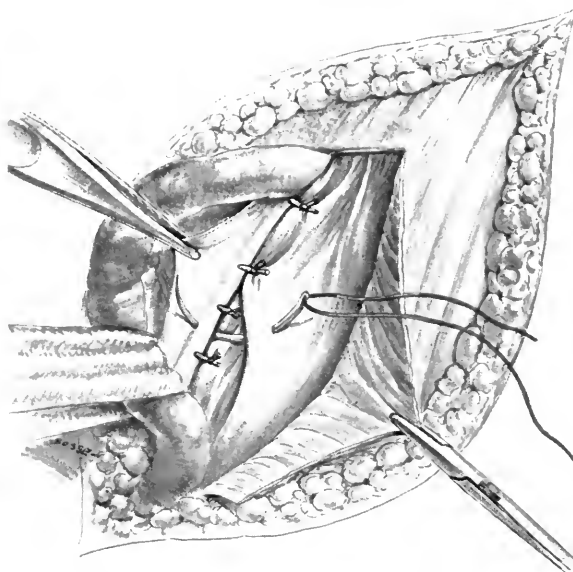


FIG. 4.—Internal oblique muscle and aponeurosis sutured well down to Poupart's over the rectus.

## RECTUS MUSCLE TRANSPOSITION

ment. Post-operative it is of advantage to allow these patients two pillows under the head and shoulders and one under the knees whenever they lie on the back for the first few days. Adequate rest in bed for sixteen to eighteen days will, I feel sure, get them back to duty with safety a month sooner than a week less in bed, and diminish their convalescent and disability time by so much. The function of sutures should be to bring tissues into apposition for union without strangulation and not to take any mechanical strain which the tissues themselves are capable of doing when firmly united by first intention.

It has not been possible to follow all the cases done in this way, not over one-third, but I know of no recurrences in over six years' experience with it. The procedure utilizing the rectus muscle in hernial repair has a definite indication and field of usefulness in a certain number of cases when the operation is made to fit the condition and not the condition a typical operation, however good that may be.

## ON THE USE OF OLIVE OIL IN BLOOD-VESSEL SUTURING

By J. SHELTON HORSLEY, M.D.

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WHILE the field for blood-vessel surgery is not a wide one, it has a distinct range of usefulness. Its use is often hindered either by unjustifiably enthusiastic and exaggerated claims of what can be accomplished, or by those who think it of no benefit in any condition. Between these extremes there is a logical middle ground. In some way an impression has gone forth that blood-vessel suturing can be done only by a few surgeons of peculiar skill and should not be employed by the average "practical" surgeon. A method that is so confined ceases to be of much real value, and any step that tends to simplify blood-vessel suturing and make it more popular is a distinct advance in the progress of general surgery.

The advantages of a technic in which a broad surface of vascular endothelium can be approximated and held by a double mattress suture, and in which all sutures can be applied under the same tension, have been pointed out in previous communications. (*ANNALS OF SURGERY*, 1912, vol. lv, pp. 208-214; *Journal of the American Medical Association*, 1912, vol. lix, pp. 4-8; *Surg., Gyn. and Obst.*, 1914, vol. xviii, pp. 536-545; and "Surgery of the Blood-vessels," by J. S. Horsley, C. V. Mosby Co., pp. 46-77.) But even with this technic which appears to overcome many objections, there is a rather constant percentage of cases in which the lumen of the vessel becomes obliterated after suturing. With more skill and experience in experimental work, this percentage of failures can be definitely diminished to about 15 or 20 per cent. in the hands of the average operator. Occlusion means technical failure. If the occlusion is sudden the vessel might as well have been ligated. If it is slow, collateral circulation may form and the function be as satisfactory as though the vessel remained permanently patent.

While this work is somewhat more delicate than the suturing of intestines, there is no reason why any competent surgeon who cares to spend a little time in experimental work cannot master the technic. He who can secure nearly 100 per cent. of successful results in experimental resection of the bowel should be able to attain more than 75 per cent. of successful results in experimental blood-vessel suturing. But 15 or 20 per cent. is too high a percentage of occlusions.

It has been considered a matter of great importance to use either vaseline or some paraffin oil in blood-vessel suturing, not only to smear over the ends of the exposed vessels, but the stitches must be impregnated in this material. It has been thought that this would both prevent drying of the vascular endothelium and seal in the tissue juices from the incised vessel walls.

Dr. J. B. Blake, of Boston, has recorded some interesting experiments in

FIG. 1



H11-

FIG. 2



FIG. 1.—Lumen of right carotid of a dog which had been severed and reunited by sutures. Specimen removed twenty-seven days after operation. In all of these specimens, olive oil was used for the sutures and to prevent the endothelium from drying. This specimen shows a perfect lumen. The sutures which are apparent in the lumen are covered with a thin layer of transparent endothelium. The reasons why the sutures are more conspicuous a week after the suturing than at the time of suturing are explained in the articles referred to in the text.

FIG. 2.—Lumen of left common carotid of a dog which had been severed and reunited by sutures. Specimen removed twenty-seven days after operation. Olive oil was used. The lumen is obstructed but not occluded.

FIG. 3



H11

FIG. 4



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FIG. 3.—Lumen of right carotid of a dog which had been severed and reunited by sutures, using olive oil. Specimen removed twenty-one days after operation. Lumen is apparently perfect.

FIG. 4.—Lumen of an arteriovenous anastomosis in which the carotid was sutured to the external jugular vein. Specimen removed twenty-one days after operation. Olive oil was used. The lumen is apparently perfect.





which he used sterile olive oil to prevent adhesions of the intestines after abdominal operations (*Surgery, Gynecology and Obstetrics*, vol. vi, 1908, p. 667). Cubbins and Abt (*Surgery, Gynecology and Obstetrics*, May, 1916, pp. 571-579) reported experiments with various substances that are supposed to prevent adhesions. Among other things they used white and yellow vaseline, albolene and lanolin, and found they had an irritating effect upon the peritoneum. They say that "vaseline is an intense irritant to the normal peritoneum of a dog, and that it is absorbed very slowly, if at all." They mention two patients upon whom they operated, in both of whom vaseline had been used in the abdominal cavity three or four months before. They say that "the walling off of the vaseline in the belly of these two humans was just as firm as if it had been around an abscess." They found that white vaseline, albolene and lanolin were as irritating as the ordinary yellow vaseline. Paraffin oil did not prevent adhesions, though it is considered "far less irritating to the peritoneum than vaseline." Olive oil, however, according to their experiments, is non-irritating and is slowly absorbed, though it prevents adhesions only in about 20 per cent. of the cases.

A substance that has an irritating effect upon the peritoneal endothelium would probably have a similar effect upon the vascular endothelium. Then, there is a possibility of absorption and oxidation of olive oil that does not occur with vaseline or paraffin oil. Bearing these facts in mind, and particularly the well proven non-irritating effect of olive oil on the peritoneal endothelium as shown by the experiments quoted, I tried olive oil instead of vaseline or paraffin oil in a few experiments in blood-vessel suturing. There were 4 experiments on two dogs. In 3 of these the carotid artery was severed and reunited, and in one, after tying the distal end, the cardiac end was sutured to the distal end of the severed external jugular vein. The technic employed is described elsewhere (*Surgery, Gynecology and Obstetrics*, 1914, vol. xviii, pp. 536-545, and "Surgery of the Blood-vessels," by J. S. Horsley, C. V. Mosby Co., pp. 46-77).

Dog No. 1, in which both carotids were severed and then sutured together, was killed under ether twenty-seven days after the operation. The right carotid, which was sutured first, showed a perfect lumen (Fig. 1). In the left carotid there was a partial occlusion, though it was not complete (Fig. 2). The endothelium is smooth on both sides of the sutures, but apparently a small clot had formed at one point on the suture line and became organized. At the tip of this small organized clot a more recent red clot had formed. This specimen was the second operation on that dog, both being done under the same anæsthetic and with the same instruments, and it is possible that some slight infection may have occurred at this point. In the other two experiments in Dog No. 2, the carotid artery was severed and reunited on one side and the cardiac end of the carotid was sutured to the distal end of the external jugular vein on the other. Both specimens (Figs. 3 and 4) showed perfect lumens when the dog was killed twenty-one days after operation. It is sometimes difficult to secure a perfect lumen in suturing an artery to a vein, but the result in this instance was entirely satisfactory.

Judging from these few experiments I believe that the use of olive oil in blood-vessel suturing will probably be attended by a larger number of successes than will the use of vaseline or paraffin oils.

The chief objection to the use of olive oil in the technic employed is that when the threads are wrapped around the buttons on the suture staff they do not hold as satisfactorily when they have been boiled in olive oil as when they have been boiled in vaseline. This can be readily overcome by smearing some sterile vaseline on the buttons of the suture staff just before the sutures are wrapped around them, and there need be no occasion for the vaseline to come in contact with the vascular endothelium.

## NOTE ON SAPHENOUS VARIX SIMULATING A FEMORAL HERNIA

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THE following case illustrates a condition which appears to enjoy the distinction of having usually led the modern clinical surgeon into diagnostic error. At least the reported cases, with few exceptions, are confessions of mistaken identity. This one was an arch-offender, having misled and humiliated in succession at least five learned and distinguished surgeons.

Mrs. R. M., white, aged thirty-eight years, was admitted to the gynæcological department of the Johns Hopkins Hospital on March 4, 1917, complaining of certain symptoms referable to her pelvic organs and of a swelling in the right groin. She had previously undergone two major operations; one four years ago for radical cure of a right femoral hernia and appendectomy, and one in January of this year for a right oblique inguinal hernia. Unfortunately, however, after both operations, when she had convalesced sufficiently to get out of bed, the pesky lump promptly reappeared in the right groin. I first saw her on March 7, 1917, a few weeks following her discharge from the hospital after the second operation. The examination disclosed a swelling the size of a hen's egg directly over the femoral canal, which promptly and completely disappeared in the recumbent posture. A definite impulse and bulging were demonstrable when the patient coughed, but I was unable to recognize either a patent femoral canal or any palpable contents of a hernia sac. The situation of the swelling was particularly interesting in its relationship to the two operative scars, one of which was above Poupart's ligament and the other at least five centimetres below and parallel to it, while the lump appeared midway between them. I made my incision directly over the tumor, but instead of directly exposing a hernia sac, I encountered in the subcutaneous tissues of the groin just over the cribriform fascia and the femoral canal a small circumscribed mass of fatty tissue containing a few lymphatic glands and a plexus of much dilated veins. Both the external abdominal ring and the femoral canal were tightly closed and there were no signs of a hernia present. By withholding the anæsthetic and permitting the patient to retch, we were able to positively exclude the existence of a hernia and to observe an enormous distention of the mass of veins. At its lower margin the internal saphenous vein was easily identified and it became obvious that we were dealing with a circumscribed varix of the upper portion of this vein together with its adjacent tributaries. The ligation and division of the trunk veins with excision of the mass of varices and fatty tissue was technically simple. It was interesting to note that there were no varicose veins lower down in the leg. At the time of her discharge from the hospital the patient was apparently cured.

A survey of the literature shows that circumscribed saphenous varix in the region of the femoral canal and external abdominal ring, while uncommon, nevertheless has long been recognized by surgeons as a condition to be differentiated from both inguinal and femoral herniæ. I have collected reports of 10 cases, the earliest being by a French observer, Boinet, in 1836. Seven of these were diagnosed prior to operation either as incarcerated or strangulated femoral hernia.

The condition closely resembles a femoral hernia not only in the size, shape and location of the tumor mass, but also in that it disappears on lying down and imparts a distinct impulse on coughing. The differential points are, first, its unusual softness; second, a perceptible thrill which is imparted to the palpating finger when the patient coughs or if slight pressure be made over the mass while the blood escapes from the dilated veins when the patient first lies down; third, having reduced the tumor, if sufficient pressure is made over the femoral canal to prevent the escape of bowel or omentum, and the patient then be allowed to stand up, the tumor will be seen gradually to reform; and, finally, the association of varicose veins lower down in the leg is frequent and is a helpful point in diagnosis.

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## THE RECURRENCE OF SYMPTOMS FOLLOWING OPERATIONS ON THE BILIARY TRACT\*

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THE prolonged and detailed discussion regarding the advisability of drainage or of removal of the gall-bladder has been valuable and convincing in that it has created a better understanding of the treatment of gall-bladder conditions. Most of us are convinced that in the majority of cases the results will be more satisfactory if the gall-bladder is removed, though I think we are also convinced that the organ has definite functions and should not be deliberately sacrificed unless there is sufficient evidence to show that it is a source of infection.

The function of the gall-bladder is not definitely known, though probably definite compensatory changes do take place when it is removed. We have reported the results of our studies of the changes that take place when the gall-bladder is removed from animals.<sup>3, 4</sup> There was no dilatation of any part of the duct if the sphincter at the ampulla was destroyed at the same time that the gall-bladder was removed. Removal of the gall-bladder in dogs, and this probably holds true for all animals and species of animals having a functioning sphincter of Oddi, produces a uniform dilatation of all the extrahepatic biliary ducts. Investigators of the subject agree that this dilatation takes place very quickly after the cholecystectomy and soon reaches its maximum development.

The process producing the dilatation probably is as follows: The liver secretes bile almost continuously, although the rate of secretion varies. The maximum intraduct pressure at which the liver can secrete is relatively low, and probably never exceeds 300 mm. of water. The escape of bile into the duodenum is at least partially under the control of the sphincter of Oddi. This sphincter when below normal in tone may be able always to withstand the pressure of 100 mm. of water and when thrown into spasm it can resist a much greater pressure, probably as high as 600 mm. of water. It is also evident that, owing to the course of the common duct through the duodenal wall, passing waves of peristalsis will momentarily prevent the escape of bile into the intestine. This fluctuation of intraduct pressure produced by the variation of the rate of bile secretion and bile escape into the intestine is, in all probability, compensated by the gall-bladder. After the removal of the gall-bladder, this mechanical action producing change in the intraduct pressure still persists, but, owing to the decrease in the total capacity of the biliary tract, the maximum pressure produced is much higher; consequently, that portion of the biliary tract most susceptible to dilatation, that is, the extrahepatic ducts, dilates. The amount of dilatation will depend on (1)

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\* Presented before The Chicago Medical Society, Chicago, February 27, 1918.

the resistance to the escape of the bile, (2) the relative capacity of the biliary tract, and (3) the resistance of the duct walls or periduct structures. The secretory pressure of the liver, although varying greatly, will always be enough to produce some dilatation of the ducts, if enough resistance is offered to the escape of bile. In cases in which the resistance to the escape of bile is low, as occurs normally in some persons because of the lack of function of the sphincter, or, experimentally, when all the muscle fibres surrounding the duct at its entrance into the duodenum have been destroyed, little or no dilatation will occur. Also, the duct will not dilate in those cases in which the capacity of the biliary tract is such that it can accommodate itself to the changes due to variation between the rate of secretion and the rate of escape. The pressure producing the dilatation is relatively quite low, probably seldom greater than 100 mm. of water, consequently, if the duct walls are resistant, or if other structures, such as the pancreas or adhesions, press on them, dilatation will not occur. In the dog, the weakest portion of the wall of the duct is at the juncture of the upper hepatic ducts. This region always shows the greatest dilatation after the removal of the gall-bladder. These results may be controlled by ligation of the common bile-duct. In a very few hours after ligation, this particular part of the biliary tract will be dilated. Whether or not the cystic duct dilates after the removal of the gall-bladder depends on these same factors. It will not dilate (1) if the resistance to the escape of bile is below the resistance of its own walls to dilatation, (2) if the capacity of the biliary tract is so great that sufficient variation in pressure does not occur to overcome this resistance, (3) if adhesions have formed around it, or (4) if other less resistant portions of the biliary tract dilate to accommodate the variation of pressure. Such dilatation has often been observed during operations on man and is especially noticeable in hydrops of the gall-bladder, in which instance the gall-bladder has been without function for some time and this compensatory change has taken place. It has also been observed in persons from whom the gall-bladder had previously been removed.

Apparently there are no untoward results from the removal of the gall-bladder. I have been able to obtain reports from fifteen persons who have been without their gall-bladders for fifteen or more years, and, so far as I can determine, they are not inconvenienced and are living normal lives. In following up these cases, it was interesting to note that one of the frequent symptoms of cholecystitis, the frequent belching of gas, persisted in several of the cases, in spite of the fact that the patients had been without their gall-bladders for so long a time. Persons who have had their gall-bladders removed also often note the passage of large quantities of bile from their bowels. They state that this may come between the normal passages; it usually occurs within the first year and may then disappear. Most persons are not disturbed by the removal of the gall-bladder. Knowing this we certainly should feel justified in removing the organ in most instances in which we believe that the immediate and ultimate results will be satisfactory.

## RECURRENCES AFTER BILIARY OPERATIONS

Some investigators are inclined to believe that cholecystitis without stones and cholecystitis with stones are two entirely distinct conditions, and that cholecystitis exists continuously without the formation of gall-stones. This would certainly point to a definite indication for the removal of the gall-bladder.

Recurrences are much more common following drainage of the gall-bladder and a definite number of such cases will require secondary operation, and while recurrences are much less frequent after its removal, there are not uncommon instances in which there was infection or stones in the ducts. Deaver reports that in 4.07 per cent. of the cases in which he operated at one hospital the operations were secondary. He says that the most common cause of recurring trouble after drainage was stones in the gall-bladder, and next in frequency were adhesions and stones in the common duct. Most of his patients required re-operation within a year. He had only re-operated in 4 cases following the removal of the gall-bladder; in 2 for stricture of the pancreatic part of the common duct; in one for stone in the common duct, and in one for duodenal fistula. He further states that removal of the gall-bladder reduces the risk of future trouble. Eisendrath has reported 11 cases of recurrence from various causes.

According to these observers and from a review of our own cases, we believe that recurrences of symptoms in biliary cases are most often due to (1) the recurrence or persistence of infection, (2) reformed or overlooked calculi, and (3) chronic pancreatitis. Faulty technic in suturing the fundus of the gall-bladder to the abdominal wall seemed to be responsible for the symptoms in a number of cases of recurrence. To adhesions have been attributed the recurrence of symptoms and undoubtedly they are a factor, though in the majority of our cases in which the adhesions were most dense there seemed to be some inflammatory trouble as an etiologic factor which produced the adhesions as well as the recurring symptoms. In some of the cases in which secondary operation was necessary the adhesions were very numerous and firm.

Dr. S. W. Harrington and I have recently reviewed the histories of patients operated on for recurrence in the past two years at the Mayo Clinic. There were 2027 operations, of which 219 (10.8 per cent.) were secondary. A large number (80 per cent.) of the operations were for the removal of the gall-bladder, a procedure which has been accepted in the clinic as the operation of choice. The drainage operation has a much higher mortality, but this is not attributed to the operation itself, since it was usually performed in cases in which the least possible operating was done because of the precarious condition of the patient, or because it was almost technically impossible to remove the gall-bladder at the time. It is our custom in badly infected cases, and in patients who are poor risks, to drain the gall-bladder at the first operation with the idea that it may possibly have to be removed at a later date when the patient is in better condition. However, if conditions are reasonably favorable, it seems advisable to remove all infected gall-bladders

at the first operation. At the present time, with a larger experience in these cases, we are removing gall-bladders which previously we believed should be drained.

One hundred and twenty of the 219 secondary operations were for the removal of gall-bladders which had been drained previously. There was only 0.8 per cent. mortality in the series, showing that the risk in the secondary operation is no greater than in the primary operation. In 4 of the 219 cases, a secondary cholecystostomy was done because the general condition of the patient contra-indicated any further procedure. Two of these patients died. In 109 of the 219 operations, calculi were found either in the gall-bladder, the ducts, or in both. One hundred and fifty-three patients had cholecystitis, in some instances associated with stones. Adhesions were especially noted in 148 cases, and in 41 there was a definite pancreatitis. Either a mucous or a biliary fistula was present in 37 cases. Seventeen of the 209 patients were definitely jaundiced. At the time of the first operation stones were found in 154 of the 219 cases; in the gall-bladder in 140, in the ducts in 9, and in the gall-bladder and ducts in 5. Stones were found at the second operation in 109 cases; in 59 cases in the gall-bladder; in 9 in the gall-bladder and ducts; and in 41 in the ducts.

In 64 of the 219 cases both the primary and secondary operations were performed in our clinic, so that we had accurate data, but in the remaining cases we were dependent for the data regarding the first operation on the history given by the patient, which in all instances was not very complete. For this reason a more detailed study has been made of the 64 cases. From 51 of the patients in this group stones were removed at the first operation, and of these stones were removed at the second operation in 35. It would seem, therefore, that in some instances at least, all of the stones were removed at the primary operation. I removed a large stone from the common duct on three different occasions from one patient. In this case, the gall-bladder was removed at the first operation and the patient was entirely free from symptoms for more than a year, and also for about one year following the second operation. It is now almost a year since the third operation was performed and there has been no evidence of trouble. It is often impossible to be certain that small stones have not slipped back into the liver, especially if the ducts are greatly dilated. When possible, the finger should be introduced into the lumen of the duct. On several occasions we have been able to wash out multiple small stones with the suction syringe. Long continued drainage with the T-tube should be instituted in some of the cases. In a considerable number of the 35 cases in which stones were removed at the second operation, drainage only was done and no attempt made to locate stones in the ducts at the first operation because an abscess was present. For this reason these cases could be designated as those of overlooked or re-formed stones. At the first operation it seemed better to relieve the infection and then remove the stones later. Some of these cases should be classified as requiring a two-stage operation, the first for drainage



of infection, usually outside the gall-bladder (in one of our cases in the sub-phrenic space), and the second for the removal of the stone and drainage of the common duct.

In 37 of the series of 64 secondary operations, a drainage operation had been performed primarily; 29 for stones and 8 for cholecystitis. Of the 29 patients with stones in the gall-bladder at the first operation, 13 had stones in the gall-bladder at the second operation, and 4 of these had stones in the ducts also. It seems almost incredible that stones could have been left in the gall-bladder, and in most of these cases I believe that they had either re-formed in the infected gall-bladder or had developed from very minute calculi buried in the mucous membrane of the organ at the time of the first operation. It is also interesting to note that of the 8 cases in which drainage was done for cholecystitis, in 2 stones or stony material which was not present at the first operation was found later. In 12 of the 64 cases, the primary operation was cholecystectomy; in 6 of these stones were removed from the common duct at the second operation. Whether or not the common duct should be opened at the time of the first operation depends somewhat on the clinical history of the case. In most instances the stones can be palpated, but even if they are not felt the common duct should be opened, provided the history is suggestive, or if there is evident inflammation in the wall of the duct. I do not believe that the common duct should be probed in every gall-bladder operation, since very little can be accomplished by probing a normal sized and normal appearing common duct. If there is sufficient evidence of a common duct infection, the duct should be opened even though no stones are palpated. This can be done in the ordinary case with little additional risk. From the number of instances in which patients are re-operated for stones in the common duct, I think we must conclude that stones will sometimes re-form in the duct.

The impressions we have gained in reviewing this series of 2027 cases are that:

1. Removal of the gall-bladder reduces the risk of later troubles, and ordinarily is to be preferred to cholecystostomy for drainage.
2. It is not necessary to open and probe the common duct at every gall-bladder operation.
3. Infection in the liver, gall-bladder, or ducts is the most frequent cause of secondary trouble, and may recur many years after the primary operation.
4. The recurrence of stones is more frequent in the gall-bladder than in any other part of the biliary tract. The common duct is next in point of frequency.
5. In a definite small percentage of cases stones will be overlooked in the common duct; in other cases the stones re-form in the duct.

The following are abstracts of the histories of 5 cases in which more than one operation was done for the removal of stones from the common duct. There was much evidence of re-formation of stones and infection in

these cases. The infection apparently persisted in some cases; in others there were no symptoms of infection over a long period.

CASE I (146221).—B. R., a male, aged sixty-two years. First operation November 26, 1915. Two soft stones one-half inch in diameter were removed from the common duct, one being impacted into the ampulla. The patient was well for a year, except that he had an occasional chill. These grew more severe, and about one year after the operation he became jaundiced. In addition to the drainage of the common duct, the gall-bladder was removed at the time of the first operation. The second operation was performed January 13, 1917. At this time stones were found in the remnant of the cystic duct as well as in the common and hepatic ducts. They contained much muddy material, and there were two large stones in the ampulla of the common duct. In this case the infection and process of stone formation apparently continued in spite of the free drainage of the ducts.

CASE II (129803).—Mrs. P. K., aged sixty-five years. First operation May 14, 1915. Several stones were removed from the common duct. A fistulous tract between the cystic duct and duodenum and also a pancreatitis were noted. The common duct was drained and the gall-bladder removed. Seven months later jaundice appeared and there was other evidence of infection in the common duct. A second operation was performed May 17, 1916, and a stone was found in the hepatic duct.

CASE III (123150).—Mrs. J. D., aged forty-one years. First operation February 1, 1915. There was empyema of the gall-bladder, and many stones were found in the common duct. A cholecystectomy was done, the stones were removed from the common duct and the duct drained. The patient felt well until three weeks before she returned for examination (January, 1916), because of an attack typical of stones in the common duct. The second operation was performed February 11, 1916, when six small stones were removed from the common duct, and several small stones were brought down from the hepatic duct with a scoop. There was some evidence of infection in the ducts and in the liver, persisting after the operation. However, there were no attacks of severe pain until March, 1917, when all the evidence of common duct stone, chills, fever, and jaundice returned. The third operation was performed June, 1917. At this time many stones were found in the common and hepatic ducts; several were wedged into the ampulla. The common duct easily admitted a finger, and a finger could also be passed into the hepatic ducts. Drainage was prolonged and the duct washed out for several weeks. The patient has remained well since the third operation.

CASE IV (99023).—Mrs. W. M., aged fifty-nine years. First operation January 20, 1914. Choledochotomy and cholecystectomy were done. The gall-bladder was large, thick-walled and filled with foul-smelling, thick bile. One large and a number of small stones were found in the gall-bladder and small stones and pasty bile in the common duct, which was drained. The patient had absolutely no trouble until

August, 1916, two years and six months after the first operation. At this time there was a typical common duct syndrome. A second operation, choledochotomy with the removal of a stone and drainage, was performed October 17, 1917. The common duct was markedly dilated and contained one stone the size of a pigeon's egg.

CASE V (177791).—A. O. H., a male, aged fifty-six years. The first operation was done November 24, 1916. The gall-bladder was very large, filled with foul-smelling bile, and contained considerable flocculent material. The common duct was one-half inch in diameter and contained a soft stone together with considerable putty-like material. Following this operation the patient regained his normal health and was well for about five months, when all symptoms of the former trouble returned. A second operation was done May 11, 1917. At this time the common duct was the size of a finger and contained a soft, crumbly stone one-half inch by one inch, which was removed from the pancreatic end of the duct.

The following are abstracts of the histories of six cases in which a cholecystectomy as a primary operation and removal of stones from the common duct as a secondary operation were done. It is probable that infection existed in the common duct in these cases at the time of the first operation, that it became active later and was the cause of the formation of the secondary stones. In some of the cases stones may have been present at the time of the first operation.

CASE VI (78278).—Mrs. E. A. R., aged sixty-one years. The first operation, a partial cholecystectomy for empyema of the gall-bladder, was performed April 23, 1913. Stones were found in the gall-bladder and cystic duct. Slight attacks occurred after the operation, although the patient was comparatively well until the fall of 1916, when the attacks became severe and there was slight jaundice. A second operation was done October 27, 1916, and two stones the size of hazel-nuts were removed from the common duct. The adhesions were very marked.

CASE VII (83151).—Mrs. P., aged thirty-eight years. The patient was operated on April 25, 1913. The gall-bladder, which was removed, was very thick-walled and contained pus and one large stone. There was one stone in the cystic duct. There were no symptoms whatever for two and one-half years, then repeated attacks of typical colic occurred. A second operation revealed a dilated cystic duct which had also been present at the time of the first operation. One stone, one-half by one-fourth inch, was found in the hepatic duct.

CASE VIII (146675).—Mrs. M. H., aged sixty-five years. This patient had been operated on elsewhere eight months previously, and stones had been removed from the gall-bladder. Eleven weeks after the operation the attacks returned. December 3, 1915, a cholecystectomy was performed. The gall-bladder was large and filled with tarry bile and stony material. The common duct was dilated, and the pancreas cedematous. February 1, 1916, a choledochotomy was done and one stone was found in the common duct.

CASE IX (6385).—J. M., male, aged fifty-eight years. The first

operation, cholecystectomy, was done November 19, 1915. Many stones were found in the gall-bladder. Pancreatitis was present. Attacks came on very soon after the operation and in a short time were very severe. A second operation, choledochotomy, was done four months later and one stone, which could not be palpated, was removed from the common duct.

CASE X (156077).—Mrs. C. H., aged thirty-eight years, gave a history of typical attacks accompanied by jaundice. Cholecystectomy was performed April 11, 1916. There were a large number of stones in the gall-bladder. The patient was well for six months, when there was a recurrence of the attacks. A choledochotomy was done March 22, 1917. The common duct was greatly distended and contained one stone.

CASE XI (54104).—Mrs. L. A., aged thirty-seven years. Cholecystectomy for cholecystitis and a large number of stones in the gall-bladder was performed July 15, 1915. The patient was fairly well for one year, when there was a recurrence of attacks similar to those she had had before operation. Choledochotomy was done at the second operation. The common duct was slightly dilated but no stone found. There was a small amount of calcareous material in the bile.

The following are abstracts of 13 cases in which the gall-bladder was drained and stones were removed at the primary operation, and in which stones were found in the gall-bladder at the secondary operation:

CASE XII (191934).—H. B. K., a male, aged forty-four years, was examined April 19, 1917, two weeks after the onset of attacks. Six severe attacks of acute pain and tenderness in the gall-bladder area without fever have occurred. There had been no chills or jaundice. He had lost 10 pounds in two weeks. No morphia had been given. The first operation, cholecystostomy for acute empyema of the gall-bladder with stones, was done April 20, 1917. The patient gained rapidly in weight and strength, but he returned later because of mucous drainage from the wound. The second operation was done May 11, 1917. There was an acute cholecystitis on a chronic condition; the gall-bladder was necrotic and a single stone blocked the cystic duct.

CASE XIII (88862).—C. L., a male, aged forty-five years, was examined July 2, 1913. He gave a history of having had three severe attacks of typical gall-bladder colic in the previous two weeks. The attacks were relieved by morphine. There had been no vomiting or jaundice. The first operation, cholecystostomy, was done August 4, 1913. One large stone and bile sand were found in the gall-bladder. The patient returned for examination in March, 1917. After having been well for three and one-half years he had had an attack of pain, three attacks in the preceding three weeks, very similar to those from which he suffered before the operation. There was no jaundice. Morphine had been given for relief. Cholecystectomy was performed March 14, 1917. Cholecystitis with one stone in the gall-bladder was found.

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CASE XIV (36335).—O. P., a male, aged thirty years, was examined April 12, 1910. He gave a history of having had in one year eight similar attacks of pain in the epigastrium radiating to the right side, to the back and shoulder. There had been no fever, vomiting or jaundice. Cholecystostomy was done May 10, 1910, many stones being removed from the gall-bladder. The patient returned, having had more or less constant trouble beginning about one year after the operation. There had been pain in the right hypochondrium, regurgitation and eructation of gas and food; the attacks lasted from two to three hours on from two to four days. The second operation, cholecystectomy, was done April 27, 1917. Subacute cholecystitis with one stone in the gall-bladder was found.

CASE XV (5704).—Mrs. J. E. S., aged forty-one years, was examined January 17, 1908. Her trouble began twenty-one years previously with indigestion, eructation of gas and food, and dull pain in the epigastrium. She was well between the attacks. Recently she had had attacks of epigastric pain more frequent and severe, requiring morphine. There was soreness but no jaundice. A cholecystostomy for stones in the gall-bladder was done January 27, 1908. The patient remained well for seven years and then began to have attacks of gastric disturbance with some pain along the right costal margin. She was well between attacks. A second operation, cholecystectomy for cholecystitis with stones in the gall-bladder, was done May 19, 1917.

CASE XVI (21761).—Mrs. F. J., aged twenty-five years, was examined June 3, 1909. Two months after the birth of her second child she began to have attacks of severe pain in the epigastrium, radiating to the back and to the right shoulder. Morphine was given. Cholecystostomy was done June 24, 1909. A large number of small stones were found in the gall-bladder. The patient remained well for seven and one-half years; she then had an attack of sudden, severe pain in the right upper abdomen with residual soreness and digestive disturbances. Physical examination revealed a mass in the right hypochondrium. Second operation May 30, 1917. Cholecystectomy for cholecystitis with stones. The large cystic duct contained a stone; the common duct was markedly dilated.

CASE XVII (27601).—Mrs. A. M. W., aged thirty years, was examined August 12, 1909. Since the patient was twelve years of age she had had innumerable attacks of epigastric pain, radiating to the back and accompanied by vomiting. The appendix had been removed five years previously but without relief. First operation August 18, 1909. Cholecystostomy for stones in the gall-bladder. A large single kidney was found. The patient remained well for five years. In the last three years she had had nine violent attacks (typical gall-bladder colic), requiring morphine. There had been no digestive disturbances between attacks. A second operation, cholecystectomy, was done July 12, 1917. Cholecystitis, a large gall-bladder filled with stones, and pancreatitis I on a scale of 4, were found.

CASE XVIII (59889).—Mrs. H. W. C., aged thirty-one years, was examined October 10, 1911. Eructation of gas and food without pain

had begun ten years previously. Such digestive disturbances continued for two years. Five years previously a sudden, severe gall-bladder colic occurred. There was no jaundice. Four similar attacks have occurred since then. Cholecystostomy was done October, 1911, for stones in the gall-bladder. The patient returned December 20, 1916. She had had no symptoms for about two years following the operation, then began having digestive disturbances, eructations of gas and food immediately after meals and pain in the region of the right shoulder. There had been no epigastric pain, no severe colics or jaundice. Second operation June 20, 1917. Cholecystectomy was done for stones in the gall-bladder. Tuberculosis of the gall-bladder and immediate vicinity was found, apparently originating near the fundus of the gall-bladder.

CASE XIX (83110).—Mrs. R. C., aged fifty-seven years, was examined April 21, 1913. The patient gave a four-year history of attacks of gall-bladder colics, gradually becoming more severe and frequent, and requiring morphine for relief. There had been nausea, vomiting, and residual soreness, and gall-stones had been passed on three occasions. A cholecystostomy was done April 23, 1913. A large number of stones were found in the gall-bladder. The patient had no trouble for three years; she then began to have attacks of pain across the upper abdomen, especially on the right side, the pain gradually becoming more severe with each attack. Morphine was given for relief. The attacks lasted from one to three hours. There was no vomiting or jaundice. The second operation, cholecystectomy, was done July 25, 1917. A large number of stones were found in the gall-bladder and cystic duct.

CASE XX (8302).—Mrs. F. W. K., aged twenty-eight years, was examined March 27, 1908. This patient had had typhoid fever when fourteen years of age and again when nineteen, and scarlet fever at the age of twelve. Her first attack came on in the fourth month of her second pregnancy. There was severe pain in the epigastrium, requiring morphine, but there was no vomiting, no jaundice or soreness following the attack. Since then she had had typical attacks every three or four months, each one becoming more severe and always relieved by morphine or induced vomiting. Thirty pounds loss of weight in the preceding six weeks. The first operation, cholecystostomy, was done March 29, 1908. Stones were found in the gall-bladder. The patient remained well for seven years and then, in the fifth month of her third pregnancy, she had a severe colicky pain in the right hypochondrium, radiating along the right costal margin to the right shoulder. She vomited and there was a questionable jaundice. Three similar attacks occurred before the child was born. During the intervals between attacks, her digestion was good. Second operation, cholecystectomy, February 3, 1916. A large number of small stones were found in a strawberry gall-bladder.

CASE XXI (92462).—Mrs. M. D., aged thirty-three years, was examined September 22, 1913. She gave a three-year history of attacks of dull pain under the right costal margin and eructations of gas and food. During the intervals between attacks she was entirely free from any disturbance. During the preceding year the attacks had been quite

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severe. The first operation, cholecystostomy, was done September 30, 1913. One stone was found in the gall-bladder. Three months after the operation the patient had a sudden attack of severe pain along the right costal margin radiating to the back. There was no vomiting, no jaundice, but some residual soreness. Two and one-half years after the operation the attacks became noticeably more severe, and cholecystectomy was done April 20, 1916. Cholecystitis with many stones in the gall-bladder was found.

CASE XXII (28466).—Mrs. H. F. D., aged thirty-five years, was examined September 1, 1909. There was a history of typical attacks of pain for six or seven years. The pain was severe, epigastric, and radiated to the back and right shoulder. A hypodermic injection was usually given. She had had three or four attacks a year, generally with vomiting. There was no mention of jaundice, fever, or chills. Cholecystostomy was done September 17, 1909. Numerous stones were found in the gall-bladder. She returned in May, 1916, having been well for four years, but during the past three years had had several attacks of severe upper abdominal pain with bloating and soreness. Morphine had been given to ease the pain. One week previous to her return she had had terrific pain in the epigastrium radiating to the back and right shoulder with vomiting, chills and fever. There had been continual aching and severe pain since that time and she gradually became more jaundiced; the temperature for three days was up to  $103^{\circ}$ . There was swelling over the area of the wound. An ice pack was applied and no food was allowed for three days. The second operation, a cholecystectomy, was done May 2, 1916. All of the gall-bladder except the bottom was removed. Acute empyema of the gall-bladder was found, the gall-bladder had ruptured at the fundus and there was an abscess in the abdominal wall and one deep in between the gall-bladder and omentum.

CASE XXIII (92367).—Mrs. G. H. P., aged thirty-eight years, was examined September 19, 1913. For three or four years she had had attacks of epigastric pain coming on every three or four months and lately she had had two or three each week, the last one three weeks previously. The pain was very severe, lasted several hours, and vomiting gave no relief. Morphine was required. The first operation, a cholecystostomy, was done April 24, 1913. A strawberry gall-bladder was found to contain numerous small mulberry stones. There was much thickening of the common duct and the pancreas was large and hard. She returned for examination in July, 1916. She had had no trouble for three years, and then began having attacks of pain which became more and more frequent—one each day. The pain started in the right epigastrium and radiated to the back, was very sharp, and required hypodermic injections. The symptoms were precisely the same as before operation. The stools were clay colored and she was apparently slightly jaundiced. The second operation, a cholecystectomy, was performed July 27, 1916. Chronic empyema of the gall-bladder and stones were found. The gall-bladder was thick-walled and red-dened, with many adhesions about it.

CASE XXIV (46235).—Mrs. M. A. G., aged thirty years, was examined November 23, 1910. For the past two years she had had many typical attacks of gall-bladder colic. There had been no nausea, vomiting, or residual soreness and very little digestive disturbance. A cholecystostomy was done November 29, 1910. Stones were found in the gall-bladder. She returned in February, 1916. About eight months after her operation she had begun to have a repetition of her former attacks, lasting for several days at a time, with epigastric pain, considerable bloating and eructations of gas or food but no vomiting, chills or jaundice. A second operation, a cholecystectomy, was done February 15, 1916. A strawberry type of cholecystitis with papillomas in the walls of the gall-bladder and one cholesterin stone was found.

#### CHOLECYSTOSTOMY AND SECONDARY CHOLECYSTOSTOMY

CASE XXV (112866).—M. O., a male, aged forty-eight years, was examined August 11, 1914. He had had attacks of typical gall-bladder colic for three years, gradually becoming more frequent and severe. Hot applications afforded relief and morphine was given for severe attacks. There had been considerable bloating, vomiting at times, no jaundice and intervals of entire freedom from any signs of trouble. Cholecystostomy was done August 24, 1914. Acute cholecystitis and many stones were found. He returned in February, 1916. He had been well for one and a half years and then had what he termed a "bilious attack." There was no further trouble for six months, and then a severe attack of right upper abdominal pain, radiating to his back and right shoulder, nausea, induced vomiting of bile and mucus, but no chills, fever, or jaundice. He had had several similar attacks since that time. A second operation, a cholecystostomy, was performed February 17, 1916. A single mulberry stone was found in the gall-bladder and pancreatitis 2 on a scale of 4.

#### CHOLECYSTOSTOMY AND SECONDARY CHOLEDOCHOTOMY

CASE XXVI (146436).—Mrs. J. K., aged forty-one years, was examined November 23, 1915, giving a history of typical gall-stone colics fourteen years previously. Eleven days previously she had had a sudden severe attack of pain in the right epigastrium, had vomited bile, had chills, was jaundiced, and had a temperature of 99°. January 7, 1915, a cholecystostomy was done. A preliminary operation was performed on account of the patient's condition. A large distended gall-bladder filled with stones and a liver twice the normal size were found. A second operation, a choledochotomy, was done February 17, 1916, with the removal of numerous stones from the common and hepatic ducts.

#### CHOLECYSTOSTOMY, SECONDARY CHOLECYSTECTOMY AND CHOLEDOCHOTOMY

CASE XXVII (58500).—Mrs. M., aged forty-one years, gave a history of thirteen years of typical attacks of gall-stone colic with jaundice. The first operation, a cholecystostomy, was performed Sep-



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tember 15, 1911. The gall-bladder was markedly infected and contained stones. After this operation the patient was well for five years and was then seized with typical gall-stone attacks with jaundice. September 5, 1916, cholecystectomy and choledochotomy were done. Cholecystitis was found with many stones in the gall-bladder, but no stones in the common duct.

CASE XXVIII (14675).—Mrs. S., aged thirty years. She had had typical gall-stone attacks for three months, but no fever or jaundice. Cholecystostomy was performed November 30, 1910, and many small stones were found in the gall-bladder. After this operation the patient was fairly well for five years, when, during pregnancy, there were occasional belching and bloating. In the last three months she had had attacks of typical gall-stone colic with chills, but no jaundice. A second operation, cholecystectomy and choledochotomy, was performed June 17, 1916. One rounded stone at the ampulla and marked cholecystitis were found but no stones in the gall-bladder.

CASE XXIX (183209).—Mrs. C. W., aged sixty-two years. She gave a six-year history of gall-stone colic without jaundice. First operation, cholecystostomy, was performed January 23, 1917. A ruptured gall-bladder was found containing stones and there was infection in the right anterior subphrenic space. She returned six months after this operation, having had three attacks of pain with jaundice, chills, and fever. A second operation was performed May 23, 1917. Cholecystectomy and choledochotomy were done. The common duct was very thick-walled and dilated, but contained no stones. There were cholecystitis, some stony débris in the gall-bladder and subacute pancreatitis.

### OPERATIONS ON THE GALL-BLADDER (NOT INCLUDING THOSE FOR CARCINOMA) IN 1916 AND 1917

OPERATIONS ON THE BILIARY TRACT, 2027; MORTALITY, 2.9 PER CENT.

Type of operation	Cases per cent.	Mortality per cent.
Cholecystectomy .....	1621 (80)	1.9
Cholecystectomy and choledochotomy .....	217 (10.7)	3.2
Cholecystostomy .....	82 (4)	8.5
Cholecystostomy and choledochotomy .....	27 (1.3)	14.9
Choledochotomy .....	39 (1.9)	12.9
Reconstruction of the ducts .....	28 (1.38)	14.0
Miscellaneous .....	13 (.6)	15.3
Secondary operations .....	219 (10.8)	5.5
Cholecystectomy .....	120 (54.7)	.8
Cholecystectomy and choledochotomy .....	32 (14.6)	3.1
Cholecystostomy .....	4 (1.8)	50.
Cholecystostomy and choledochotomy .....	3 (1.3)	0.
Choledochotomy .....	35 (16.)	14.2
Reconstruction of the ducts .....	21 (9.5)	9.5
Miscellaneous .....	4 (1.8)	25.

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SECONDARY OPERATIONS, 219; MORTALITY, 5.5 PER CENT.

	Cases per cent.
Cholelithiasis .....	109 (49.7)
Cholecystitis .....	153 (69.8)
Adhesions .....	148 (67.5)
Pancreatitis .....	441 (18.7)
Fistula .....	37 (68.8)
Strawberry gall-bladder .....	34 (15.5)
Jaundice .....	17 ( 7.7)
Trabeculation .....	11 ( 5. )
Stricture .....	8 ( 3.6)
Papilloma .....	7 ( 3.1)

Stones found at first operation in 154 cases; 70.3 per cent.:

	Cases	Per cent.
In the gall-bladder in .....	140	(90.9)
In the ducts .....	9	( 5.8)
In the gall-bladder and ducts .....	5	( 3.2)

Stones found at the secondary operation, 109 cases; 49.7 per cent.:

	Cases	Per cent.
In the gall-bladder in .....	59	(54.1)
In the gall-bladder and ducts .....	9	( 8.2)
In the ducts .....	41	(37.6)

Previous operations on the gall-bladder in the Mayo Clinic, 64 (29.2).

Of the 64 cases, stones were found at first operation in, 51 (79.6).

Of the 51 cases, stones were found at second operation in, 35 (68.6).

## 64 SECONDARY OPERATIONS ON THE GALL-BLADDER IN 1916 AND 1917

### TYPE OF FIRST OPERATION

	Cases
Cholecystostomy (for stones 29; cholecystitis 8).....	37

### TYPE OF SECONDARY OPERATION

	Cases
Cholecystectomy (for stones 13; for cholecystitis 5).....	18
Cholecystostomy (for stones in the gall-bladder).....	1
Choledochotomy (for stones in duct).....	1
Choledochotomy and cholecystectomy (for stones or stony material in the gall-bladder or ampulla).....	3
Cholecystectomy (for cholecystitis without stones).....	6
Cholecystectomy (for stones or stony material in the gall-bladder 2 cases; for cholecystitis without stones 6 cases).....	8

### TYPE OF FIRST OPERATION

	Cases
Cholecystectomy (for stones 10; for cholecystitis 2).....	12

### TYPE OF SECONDARY OPERATION

	Cases
Stones at the first operation .....	10
Choledochotomy (for stones in the ducts 6; small ducts—adhesions infection 2)....	8
Reconstruction of ducts .....	2
Choledochotomy (for partial obstruction of common duct—many adhesions and distended hepatic duct).....	1
Reconstruction of the common duct (tremendous adhesions, but condition not sufficient to account for symptoms).....	1

# RECURRENCES AFTER BILIARY OPERATIONS

## TYPE OF FIRST OPERATION

	Cases
Choledochotomy and cholecystectomy (for stones in ducts).....	7

## TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (for stones and bile sand in ducts).....	6
Reconstruction and choledochotomy (stricture of common duct, and tumor of cystic duct) .....	1

## TYPE OF FIRST OPERATION

	Cases
Choledochotomy and cholecystectomy (for stones in ducts and bladder).....	3

## TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (stone in the common duct).....	1
Cholecystectomy (cholecystitis with multiple small cysts in the mucosa).....	1
Cholecystenterostomy (tense gall-bladder filled with bile—fistula arising from the common duct—infection of the gall-bladder—much oozing from all the tissues) .....	1

## TYPE OF FIRST OPERATION

	Cases
Choledochotomy (stones in the hepatic duct).....	2

## TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (greatly dilated ducts, no stones, pancreatitis 3).....	1
Partial cholecystectomy (empyema of the gall-bladder, no stones, a great many adhesions) .....	1

## TYPE OF FIRST OPERATION

Drainage of a subphrenic abscess (preliminary to further operation).....	1
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## TYPE OF SECONDARY OPERATION

	Cases
Cholecystectomy and excision of the sinus tract for ruptured gall-bladder and stone in the sinus tract .....	1

## TYPE OF FIRST OPERATION

	Cases
Reconstruction of the hepatic duct (biliary fistula, dense adhesions).....	2

## TYPE OF SECONDARY OPERATION

	Cases
Reconstruction of the ducts (hepatic duct opened at the point of union with the stomach—stone removed from the hepatic duct).....	1
Opening in the hepatic duct much contracted; this was enlarged and the anastomosis separated .....	1

## TYPE OF FIRST OPERATION

	Cases
Choledochotomy (stones in hepatic duct).....	2

## TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (greatly dilated ducts—no stones—pancreatitis 3).....	1
Partial cholecystectomy (empyema of gall-bladder—no stones—great many adhesions) .....	1

# E. S. JUDD

TYPE OF FIRST OPERATION		Cases
Drainage of subphrenic abscess (preliminary to further operation).....	1	1
TYPE OF SECONDARY OPERATION		Cases
Cholecystectomy (excision of sinus tract of ruptured gall-bladder and stone in sinus tract) .....	1	1
TYPE OF FIRST OPERATION		Cases
Reconstruction of hepatic duct (biliary fistula—dense adhesions).....	2	2
TYPE OF SECONDARY OPERATION		Cases
Reconstruction of duct (hepatic duct opened where it was united to stomach and the stone removed) .....	1	1
Reconstruction of duct (the opening in the hepatic duct was much contracted and was enlarged—anastomosis separated).....	1	1
TYPE OF FIRST OPERATION		Cases
Cholecystectomy (for stones 10; for cholecystitis 2).....	12	12
TYPE OF SECONDARY OPERATION		Cases
Stones at the first operation .....	10	10
Choledochotomy (for stones in ducts 6; small ducts—adhesions—infection 2).....	8	8
Reconstruction of ducts .....	2	2
Choledochotomy (for partial obstruction of common duct—many adhesions and distended hepatic duct) .....	1	1
Reconstruction of common duct (tremendous adhesions, but condition not sufficient to account for symptoms).....	1	1
TYPE OF FIRST OPERATION		Cases
Choledochotomy and cholecystectomy (for stones in ducts).....	7	7
TYPE OF SECONDARY OPERATION		Cases
Choledochotomy (for stones and bile sand in ducts).....	6	6
Reconstruction and choledochotomy (stricture of common duct, and tumor of cystic duct) .....	1	1
TYPE OF FIRST OPERATION		Cases
Choledochotomy and cholecystostomy (for stones in ducts and gall-bladder).....	3	3
TYPE OF SECONDARY OPERATION		Cases
Choledochotomy (stone in common duct).....	1	1
Cholecystectomy (cholecystitis with multiple small cysts in mucosa).....	1	1
Cholecystenterostomy (tense gall-bladder filled with bile—fistula arising from common duct—infection of gall-bladder—much oozing of all tissues).....	1	1

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## ACUTE DILATATION OF THE STOMACH FOLLOWING PROSTATECTOMY

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IT is not my object to discuss the various theories that have been advanced from time to time regarding the etiology of this condition, for as yet the etiological factor or factors are unknown; nor is it my intention to review the literature of the subject, inasmuch as this has been extensively done recently by Lee, Colin, Laffer and Borchgrevink; but I shall report a case in which this condition followed suprapubic prostatectomy. Besides reporting cases occurring in the practices of the authors, the above-mentioned articles contain extensive bibliographies, Laffer having reviewed 217 reported cases and Borchgrevink analyzed 144 cases from the literature. Those interested in this subject are referred to these publications.

That acute dilatation of the stomach following suprapubic prostatectomy is a rare complication is evidenced by the fact that in the above-mentioned extensive reviews not one instance is mentioned in which this condition complicated suprapubic prostatectomy. Nor have I been able to find in the literature at my command a single recorded case, so that this case which I shall cite is probably the first to be reported in this country. The reasons for this scarcity of literature on this complication will be discussed below.

Therefore, the extreme rarity of acute dilatation of the stomach following prostatectomy seems to me to justify the reporting of the following case:

G. C. M., male, aged sixty-three, was admitted to the Presbyterian Hospital, September 23, 1916, referred by Dr. C. McCullough.

*Past History.*—The patient had the usual diseases of childhood. At the age of twenty-seven he had a Neisserian infection, which was followed by stricture and treated by the use of sounds. He has been troubled with frequency of urination for about fifteen years, being obliged to arise about once at night during all this time; of late, two or three times a night. The frequency is always worse during cold weather.

*Present Complaint.*—The patient comes in complaining of pain in the bladder and back and inability to urinate. During the past year there has been more or less difficulty in urination, so that the patient has had to strain in order to start the stream. The stream has been very slow and dribbling was present at the end of urination. There has been some pain associated with the straining, but no burning. Four days ago the patient had severe pain in the bladder and a dull

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\* Read at the meeting of the Chicago Urological Society, November 15, 1917.

aching pain in the back. At this time the patient was unable to urinate. He was catheterized and 50 ounces of urine were obtained. In twelve hours he was again catheterized and 50 ounces of urine were obtained. Patient has passed no urine for four days and has been catheterized since the onset of the present attack of retention.

*Examination.*—The patient is a large, well-nourished man. The pupils are equal and react to light and accommodation. The teeth are in rather poor condition and the tonsils are large. The thyroid is normal. The heart, L. H. B. is 9 cm. from the M. S. L., R. H. B is 2 cm. from the M. S. L.; tones are clear and regular. The liver border is palpable at the costal margin. The abdomen is large and distended, with the lower portion dull at the site of the bladder. The external genitalia are negative. The extremities are normal.

*Rectal Examination.*—The prostate is very large, soft and not tender. It is as large as a grape-fruit. On admission to the hospital the patient was catheterized and 52 ounces of urine were obtained. The catheter passed the prostate with difficulty. Blood-pressure: Systolic, 130; diastolic, 90. Urinalysis: Specific gravity, 1018, acid, trace of albumin, no sugar or acetone. Few fine granular casts, few pus-cells, but no blood. Röntgen ray examination: Negative for the presence of stones. Phenolsulphonephthalein test: Time of appearance, 11 minutes. Output first half hour, 27.8 per cent.; second half hour, 11.5 per cent.; total, 39.3 per cent.

Urinalysis (September 24, 1916): Cloudy, amber, 1025, acid, erythrocytes, +; leucocytes, + +; cell count shows 475 pus-cells per c.mm.

Cystoscopy could not be carried out as it was impossible to introduce the cystoscope because of the obstruction due to the enlarged prostate.

*Suprapubic Prostatectomy* (September 27, 1916).—Ether anaesthesia. An incision was made in the midline from symphysis to umbilicus. The peritoneum was stripped back from the bladder and the bladder opened. The prostate was enucleated in two minutes. The bladder was then packed for a few minutes. This was followed by a rather severe hemorrhage, which gave a great deal of trouble until it was controlled. This was done by packing the wound very tightly with gauze. The incision was closed with deep catgut sutures and silk-worm-gut sutures closed the skin.

*Post-Operative Course* (September 28, 1916).—Dressings moist and very slightly tinged with blood. During the day the patient had four attacks of vomiting, vomiting at each time from 150 to 200 c.c. of greenish fluid. There was very little nausea.

September 29, 1916: Abdomen quite distended. At 8.30 A.M. the patient vomited 500 c.c. of a dark greenish fluid. The gauze packings were removed from the bladder. During the night he vomited a small amount of fluid and was still nauseated.

September 30, 1916: The patient had ten attacks of vomiting during the twenty-four hours. The amount vomited varied from 150 to 360 c.c. At 10.45 A.M. the stomach was aspirated and 400 c.c. of foul-

## STOMACH DILATATION AFTER PROSTATECTOMY

smelling fluid obtained. This was followed by gastric lavage with sodium bicarbonate. Eight hours later the patient had a second gastric lavage with sodium bicarbonate. At this time the pulse was rapid, of poor quality and the patient had some hiccough. The dressings were saturated with urine, but no blood.

October 1, 1916: The patient continued to vomit large amounts of foul-smelling fluid. At the first aspiration 300 c.c. of fluid were obtained. At the second, made seven hours after the first, 1500 c.c. of dark brown fluid were obtained. Each aspiration was followed by a gastric lavage with sodium bicarbonate.

October 2, 1916: Three aspirations were carried out. At the first, 1000 c.c. were obtained; at the second, 600 c.c., and at the third, 400 c.c. Each aspiration was followed by gastric lavage with sodium bicarbonate. The dressings were saturated with urine. The pulse was very poor.

The patient died at midnight October 3, 1916. The dressings were saturated with urine. The pulse could not be felt and failed to respond to stimulation. Unfortunately, an autopsy could not be obtained.

Besides gastric lavage, the patient was given digipuratum, strychnia and caffeine citrate, and normal saline solution per rectum and subcutaneously to make up for the loss of fluids.

The recent interest displayed in the subject of acute post-operative dilatation of the stomach has revealed the fact that this condition is not as rare as was formerly supposed. Certain phases of this subject remain unsolved, chief of which are the etiology and pathogenesis. Although one generally thinks of acute dilatation as a surgical complication, there are many instances in which this condition has occurred in patients who were not subjected to surgical intervention. Thus, cases do occur in strictly medical conditions, cases having been reported in which this occurred during pneumonia by J. B. Herrick, Houssen, Lehman, Box and Wallace and Leonhardt. Furthermore, cases have been reported that occurred during typhoid fever by Wichern, Baumler, Heine-Ewald and others. Albu reported a case occurring on the eleventh day of scarlet fever and Bloodgood a case that occurred after acute rheumatism. Not only has dilatation of the stomach occurred during the acute infectious diseases, but it has been seen in the course of chronic illnesses, such as pulmonary tuberculosis, diabetes and sciatica.

Trauma, such as a blow upon the abdomen, has been mentioned as a factor in a few instances. Even pregnancy may be complicated by gastric dilatation (Laffer, Thomson, Campbell), and in rare instances it has occurred after rupture of an extra-uterine pregnancy. Cases associated with over-eating or the taking of large amounts of fluid, hasty eating, etc., have been reported by Bastedo, Hoffman, Brown, Körte and others. To this group may be added the cases occurring in infants. That infants do not escape this disease is evidenced by cases reported by Beck, Belilios and Cooper. Kundrat also called attention to its occurrence in infants.

These instances of its occurrence are briefly mentioned to show that this condition does occur independently of surgical operations. It is, however, as a surgical complication that dilatation of the stomach has received more clinical study, as most of the cases reported have followed surgical operations. By far the largest number of cases have followed operations within the peritoneal cavity. That it can and does occur after operations other than laparotomies is also well known, for cases have been reported which occurred after operations on the head, such as drainage of the antrum of Highmore, after operations on the extremities, as resection of the hip-joint, amputations and operations for osteomyelitis. Operations on the genito-urinary organs likewise have been followed by gastric dilatation. Thus this condition has been reported as following an external urethrotomy (Braun and Seidel), as well as operations upon the kidney (Borchgrevink, Legueu, Payer-nephrectomies, and Borchardt-nephropexy).

As previously stated in this paper I have not found a case reported in which this condition followed prostatectomy, and one is therefore forced to come to one of three conclusions regarding the occurrence of this condition as a complication of prostatectomy:

1. Either this entity as a complication of prostatectomy is very rare;
2. That the condition does occur but is not recognized—which from the gravity of the symptoms hardly seems possible;
3. Or that cases do occur, are recognized, but not reported because of their generally fatal termination.



## THE MECHANISM OF OBSTRUCTION IN PROSTATIC ADENOMA

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THE mechanism of retention of urine in prostatic adenoma has not been adequately explained. During the past few years the conclusions reached by a number of investigators dealing with the mechanism of prostatic obstruction have been that prostatic enlargement is not the cause of prostatic retention. To support this contention, cases are cited to show that prostatic enlargement often occurs without retention. According to Sir Henry Thompson, not more than half of those with enlarged prostates suffer from retention. On the other hand, it is well known that retention often occurs without prostatic enlargement. This group of cases, the *prostatisme sans prostate* of Guyon and his followers and the distinct types of retention of urine due to central nervous diseases, will not be included in this discussion.

The usual varieties of obstruction at the bladder neck or in the prostatic urethra may be classified as follows:

1. Median lobe hypertrophy, including the pedunculated form.
2. Lateral lobe hypertrophy, without recognizable median lobe involvement.
3. General hypertrophy, involving all five lobes, or more particularly the lateral or median lobes.
4. Hypertrophy of the submucous glands of Albarran.
5. Contracture of the neck of the bladder, often termed the fibrous median bar.

The site of the obstruction in prostatic adenoma has been placed by some investigators at the neck of the bladder. According to Keyes,<sup>1</sup> a finger introduced into the prostatic urethra through a perineal opening encounters an abnormally elevated prominence on the floor of the urethra at the neck of the bladder. He believes that this prominence is the cause of prostatic retention. However, the precise manner in which this obstruction interferes with the urinary flow has never been definitely proven. According to some observers, this prominence interferes with the normal action of the internal sphincter and thus produces retention.

In considering other theories that have been advanced to explain retention, it may be said that some hold that the compression of the urethra by enlarged lateral lobes cannot in itself cause retention. In fact, it has been shown that instead of being strictured, the posterior urethra is more often dilated in prostatic adenoma and that frequently there is no obstruction to the passage of a large-sized catheter as it enters the bladder. This being

<sup>1</sup> Keyes, E. L.: The Mechanism of Prostatic Retention. Journal A. M. A., v, May, 1914.

the case, it would hardly seem possible that there could be any interference with the urinary flow. However, a condition somewhat similar to be found is contracture of the neck of the bladder. In this disease it is well known that a full sized sound may be introduced into the bladder without marked difficulty, and the patient nevertheless suffers from urinary symptoms and frequently from retention of urine.

It is obvious in looking for an explanation into the mechanism of prostatic obstruction in prostatic adenoma, that no one factor can be made to apply to all the forms of prostatic enlargement. In the small number of cases where a distinct pedunculated median lobe or hypertrophied Albarran submucous glands are present, the mechanism of retention is readily explained by the obvious nature of the obstruction. In the larger group of

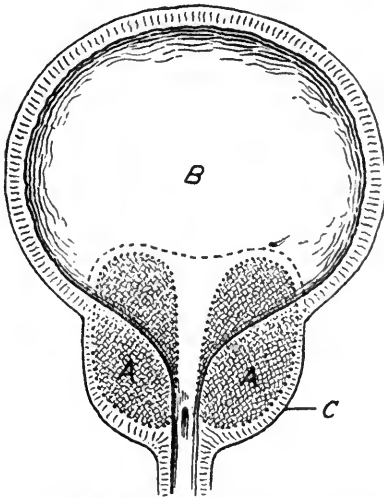


FIG. 3.—AA, adenomata in position of rest; B, bladder; C, resistant capsule.

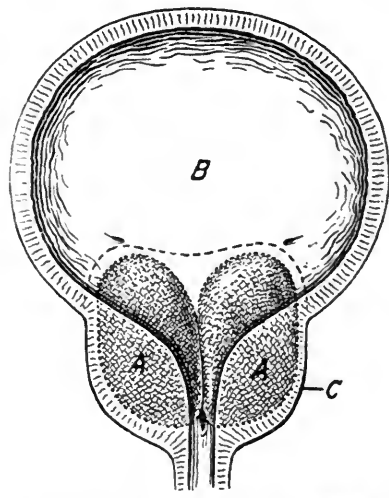


FIG. 4.—AA, adenomata compressed by hydrostatic (increased) pressure approximating on the broadened urethra; B, contracting bladder plus increased abdominal pressure; C, resistant capsule.

prostatic hypertrophies involving the lateral lobes the mechanism is entirely different. The site of the obstruction which is in the prostatic urethra can be readily demonstrated with a posterior irrigating urethroscope, or the close vision convex sheath of the Buerger-Brown cystoscope. The enlarged lobes of the prostate are distinctly seen as two generally symmetrical masses, lying on either side of the urethra extending from immediately beyond the internal urethral orifice to a short distance below the verumontanum. The urethra occupies a groove between these large masses. In normal respiration the lobes are separated from each other; in deep respiration they are seen to be farther apart, and a wider strip of the urethra is visible. When the patient is asked to strain, simulating the condition in urination against obstruction, the lateral lobes are brought into close apposition for practically their entire length, thus obliterating the lumen of the urethra. The prostatic adenomata acts as a potential obstruction in the posterior urethra. The intra-



FIG. 1.—Urethroscopic picture of post-urethra in normal respiration.

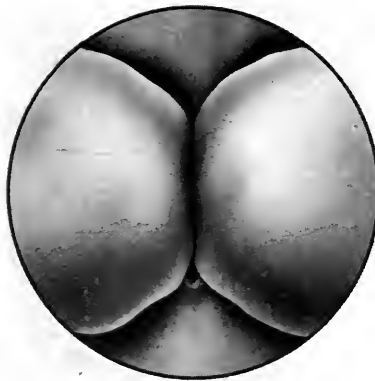


FIG. 2.—Urethroscopic picture of post-urethra during act of straining.



abdominal pressure and hydrostatic pressure of the full bladder transform this potential obstruction into an actual one. During the act of micturition or straining the elastic adenomata are squeezed down, and being surrounded by a dense fibrous capsule, can give way in only one direction and that towards the prostatic urethra. Thus the lateral lobes are brought into close apposition shutting off the canal. Beer,<sup>2</sup> who first called attention to this mechanism, describes it as the "vocal cord" play of the prostatic lobes. His explanation of the manner in which the lateral lobes act in producing obstruction is as follows: "Under the increased intra-abdominal pressure the prostatic adenoma is forced down in straining into the prostatic capsule and the wide posterior urethra is compressed from side to side, thus producing obstruction to the outflow of the urine. This explains the fact so often observed in these cases, that "the harder they strain, the more difficult it is to empty the bladder." On the other hand, in those cases of moderate lateral lobe enlargement in which retention is not present one notices through the urethroscope that the lobes are not in close apposition in the act of straining, that the urethra is not compressed, and that there is a sufficiently large trough for the escape of the urine.

In conclusion, therefore, I am of the opinion that obstruction to the outflow of the urine in cases of lateral lobe enlargement is potential, and regularly due to blockage of the urethra by the lateral lobes during efforts of forced urination.

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<sup>2</sup> Beer, E.: Adenoma of the Prostate. *Medical Record*, March 14, 1914.

## TERATOMA OF THE SACRUM: GLIOMA OF THE UPPER ABDOMINAL CAVITY \*

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It appears to me that neoplasms should be studied from three distinct standpoints, the anatomical, histological and histogenetic. The anatomical appeals most to the practical surgeon, because it enables him to remove the growths safely and radically, and in so doing to satisfy both the immediate needs of the patient and his own standards of good work. Histological study follows closely on this, so closely, in fact, that in some clinics a histologic diagnosis is given to the surgeon before the operation is completed, and, if the case demands it, before complete removal of a tumor is attempted. Histogenetic study, *i.e.*, the study of the origin of the cells of the tumor, is usually relegated to the pathologist, receiving, I am sorry to say, but scant attention from the surgeon as being a matter of mere didactic interest, with little practical bearing. Such a mental attitude is to be deplored, because it shuts the surgeon completely out of the romantic atmosphere of his specialty and reduces him to a mere materialist. The reproach has often been hurled at surgeons that they were degenerating into clever craftsmen doing what they were told to do by the internists without personal knowledge of the reasons for operating. In some degree this reproach has been earned. The surgeons we revere most, like John Hunter and Billroth, were consummate pathologists.

If any apology is needed for the report of the two following cases, it lies in the hope of placing before you in as simple a manner as possible the etiology of the reported tumors from an embryological standpoint.

CASE I.—*Teratoma of the sacrum.* A female white baby, aged six months, came under my care suffering from a large tumor attached to the lower end of the sacrum and coccyx. At birth the tumor was about the size of an orange. The baby was well nourished and continued to grow normally and steadily without any interference with the natural bowel movements. The tumor seemed to increase in size proportionately with the growth of the child, until the child reached the age of five months, when the parents became alarmed by rapid growth of the tumor. When the case came under my observation the tumor was as large as a cocoanut. It occupied the region between the lower end of the sacrum and the anal orifice, which latter was somewhat prominent and distorted. The growth was globular in shape, smooth in outline, elastic to the feel, and of homogeneous consistence. No cysts could be discovered. The skin was freely movable over its surface. It was

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\* Read at the meeting of the Southern Surgical Association, December, 1917.

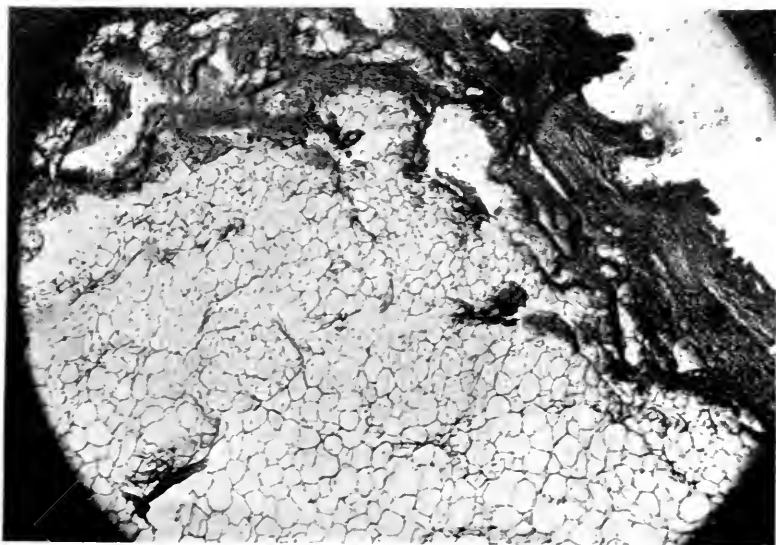


FIG. 1.—Shows fat composing the bulk of the tumor, like normal fat in appearance microscopically, but grossly very light in color. At one corner of the section is seen the wall of a cyst with epithelial lining. Later figures will show this cyst wall more perfectly.

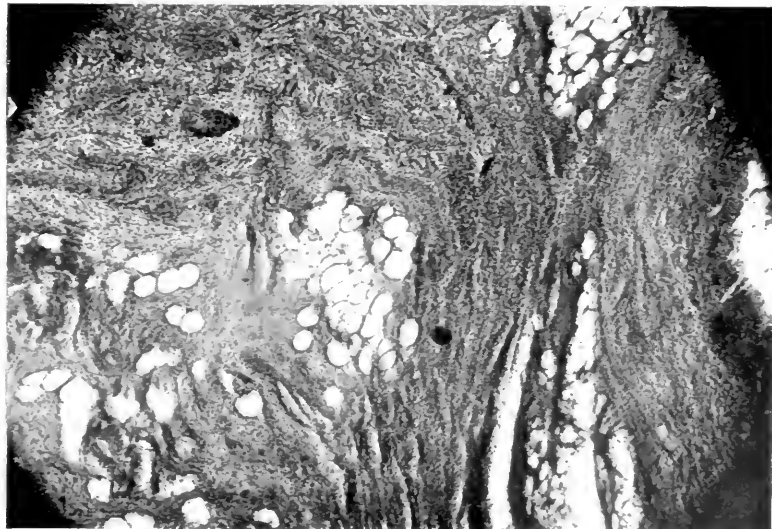


FIG. 2.—Shows an area of fibrous tissue, embryonic in type, infiltrating the fat. Grossly this is white fibrous tissue similar to that in the fibroma molle found in the uterus. This is slightly softer and more cellular than adult fibrous tissue. Mixed with it are some areas of fatty tissue.



FIG. 3.—This figure shows cartilage, embryonal in type, similar to adult hyaline cartilage but containing more cells. This and the two preceding figures are of mesodermal origin.

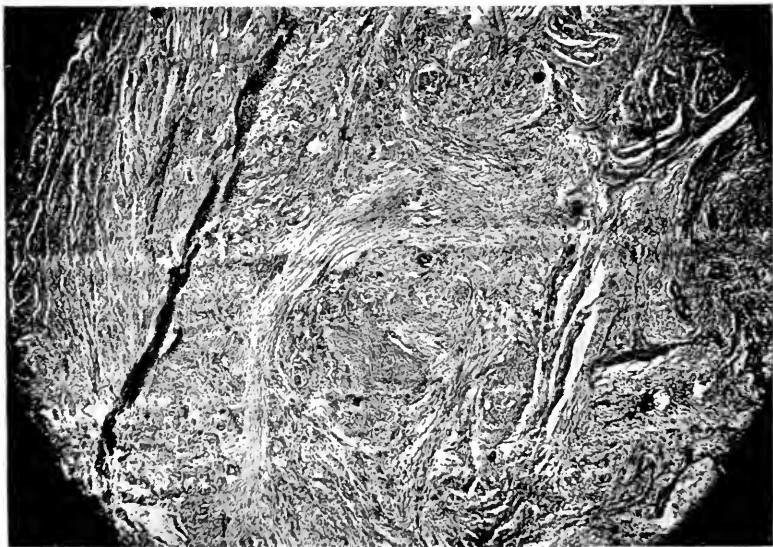


FIG. 4.—This section is taken from one of several small irregular areas, grayish pink in color, imbedded in the fat of the tumor. One or two of these contain small cystic cavities. Microscopically, as will be seen from the section, these areas resemble neuroglia. In the gross specimen, also, their color and appearance is very suggestive of nervous rather than of fibrous tissue.



FIG. 5.

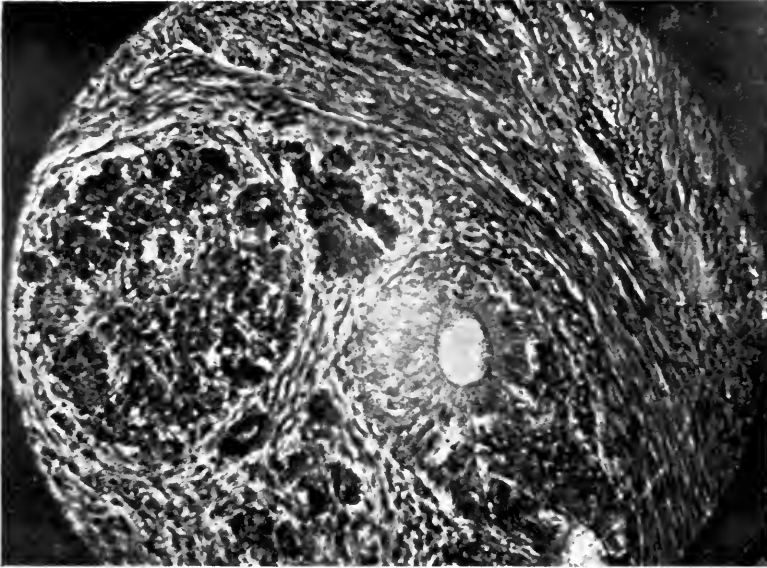
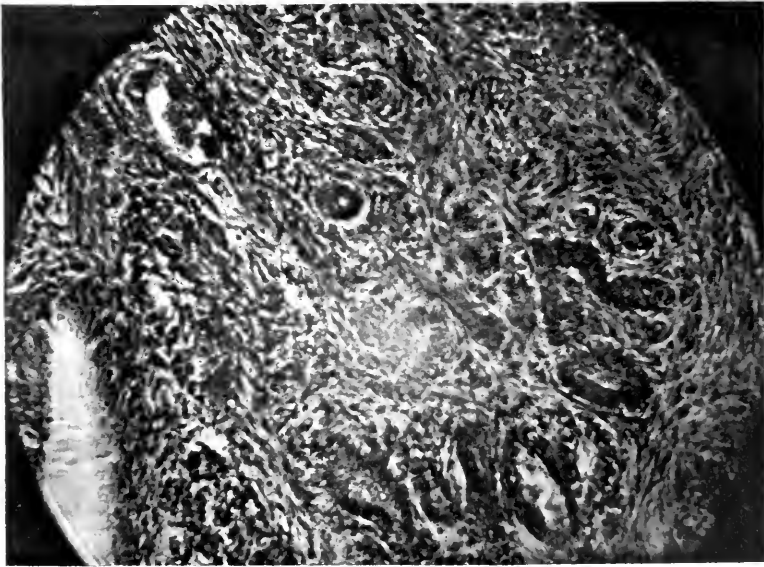


FIG. 6.



FIGS. 5 and 6.—Higher power pictures of the same area. In these some of the cells have a definite ependymal character, being arranged in a radial manner. Only a neuroglia stain would differentiate these areas positively from gland tissue; but the conjunction of cells arranged in this way with tissue so much like gliomatous tissue is fairly definite evidence of their glial character, and if glial, they are of ectodermal origin.



FIG. 7.—This shows the wall of a papilliferous cyst imbedded in the fatty material, containing a thick, tenacious, clear mucus, like normal mucus and not like the mucoid or gelatinous material usually found in tumor cysts. This tissue is suggestive of gastro-intestinal mucosa and therefore seems to be hypoblastic in origin. Unfortunately, mesoblast also gives rise to mucous glands (uterus, *e.g.*). The lining epithelium is simple columnar with goblet cells and simple tubular glands opening into the cyst. Deep in the tissue, it is difficult to tell whether the radial collections of cells are glandular or ependymal; the differential neuroglia stain is very uncertain in its results and an attempt made upon this was a failure—failing, also, in spinal cord—so that it proved nothing. In places the epithelium lining the cyst walls is stratified squamous.



FIG. 8.—This shows another section of a cyst wall, a part of the same cyst in which the deeper layers are more definitely fibrous. The papilliferous arrangement is very accentuated.

firmly fixed to the sacrum and coccyx. Digital examination of the rectum revealed nothing abnormal. The mucous membrane was intact and free from signs of infiltration. It could not be moved freely from the growth. X-ray examination was negative as to the presence of bony or calcareous masses. A diagnosis of congenital sacral tumor was made.

*Operation* (February 11, 1915).—Ether anæsthesia. A transverse incision was made over the middle of the growth and the skin retracted upward and downward. The dissection was comparatively easy. The lower end of the sacrum was divided and the growth enucleated from above downward. In this way the rectum was exposed high up, as in a Kraske operation, and the deep dissection carried out under the eye. The rectum was not seriously hurt, only a trifling amount of muscular tissue being removed with the growth. The sphincter muscles were undisturbed. Convalescence was ideal, being unattended by any disturbance of the rectal functions. At the present time of writing (December, 1917) the child is in perfect health.

*Description of Tumor*.—The tumor was as large as a cocoanut and showed the lower part of the sacrum and coccyx spread on its posterior wall. On section, it appeared for the most part of a yellowish-white color, and of a firm homogeneous consistence. It looked like dense fat. Numerous serial sections were made which for the most part presented the appearances described below. In addition, a number of islands of cartilage were found, one of them being of considerable size; also a few smaller islands of irregular shape and of a grayish-pink color which strongly resembled the tissue of the brain; and also a number of cystic cavities, one of which was of considerable size.

The microscopic features are shown in Figs. 1-8, for which and the attached legends I am indebted to my friend and colleague, Dr. V. H. Keiffer.

The case conforms to the type of congenital sacral tumors that have been hitherto described,<sup>1</sup> *i.e.*, it contains elements of all the three embryonic layers (*epiblast*; neuroglia: *hypoblast*; glands: *mesoblast*; fat, fibrous tissue and cartilage).

The exact origin of these growths has never been settled definitely. The theory usually advanced is that they are derived from the vestiges of the neuro-anal canal and the post-anal gut. Another theory, *viz.*, that they are the result of fetal inclusion, has little to recommend it, because there is no reason why fetal inclusion should occur in this particular part of the body.

In all probability the real explanation is to be found in unusual and misplaced activity of the posterior growing point of the embryo. This theory is defended strongly by Adami, whose able arguments and clear reasoning appear to settle the question conclusively. The following description is taken from his text.<sup>2</sup> It is based on our knowledge of the growth of a plant. "If we consider that the first cell divides into two and then into

<sup>1</sup> Schwalbe: *Morphologie der Missbildungen*.

<sup>2</sup> Adami: *Text-book of Pathology*, p. 815.

four, and each of the four again into two, we find that the two poles tend to become separated one from the other and each pole is advanced by the cells that are built in behind it. There are in the plant, from an early stage, two primary growing points—the superior forming the stalk and the inferior the root; the entire plant arises from one or other of these ‘points’ and the growing point is the most advanced part of the plant; the plant increases by growth backward and not forward from the growing point whose position is thus fixed at its apex.

“The growing point does not grow forward, but is projected forward by the intercalation of the daughter cells behind it and the daughter cells are able to divide in a transverse way and give rise to special tissue cells. Secondary growing points can subsequently arise from the daughter cells, but their vegetative function must be exercised now in a direction more or less lateral and no longer axial. Similarly in animals, there are two ‘growing points’: the superior growing point is represented in the adult mammal by tissue about the situation of the pituitary body, and the inferior by tissue somewhere in the sacral region. These two points lie beyond the extremities of the chorda dorsalis, an organ whose prominence in the early embryo and whose apparent unimportance in the formed foetus suggest that its function may be partly the keeping of the growth axially, as a scaffolding might do in the earliest stages. These two growing points from the very origin of the embryo are being projected apart, and the successive daughter cells given off from these give origin to the different organs of the body and even form secondary growing points for the limbs.” . . . “But there is a fundamental difference to be observed. Whereas in the plant the primary growing points are active during the whole of its existence, in the animal they cease to functionate as such when the anlagen of the brain and the rest of the nervous system have been developed.

“The cells of the growing points consist of totipotent cells which are capable of giving rise to tissues of all orders belonging to the three primitive germinal layers. If, therefore, the growing points continue active, large masses of such tissue may be formed at either end of the body. These masses may contain bone and soft tissues representative of meso-, epi- and hypoblast. Those occurring at the anterior end of the body arise from the base of the skull just behind the pituitary fossa. They are spoken of as epignathus. Those at the posterior end of the body are situated at the lower end of the sacrum and form the congenital sacral tumors.”

CASE II.—*Glioma of upper abdominal region.* C. A., aged thirty-nine, male, colored, was admitted to the John Sealy Hospital on November 21, 1917, suffering from a large tumor situated in the upper abdominal region.

*History of the Disease.*—About four months ago he noticed that his stomach was becoming bigger. He was then a large man, weighing about 200 pounds, and as he suffered from no pain or other discomfort he thought he was getting fatter. The tumor grew rapidly and he

lost about fifty pounds of weight in four months. He believed it showed itself first in the neighborhood of the umbilicus. There was no fever. It was his first sickness, so he did not seek advice, until the size of the tumor alarmed him. The day before admission to hospital he had slight pain over the tumor, which spread to the pit of the stomach and over the left side of the chest.

*Previous History.*—Gonorrhœa at the age of twenty-one. No history of syphilis; had been an unusually strong and healthy man. No history of dyspepsia or any stomach trouble.

*Present Condition.*—The patient looked fairly well nourished and weighed about 150 pounds. He complained of nothing but the inconvenience of the abdominal tumor. It was not painful, nor was it tender on reasonable manipulation. The tumor was large. It reached from about two fingers' breadth below the umbilicus to the upper part of the epigastrium, the left side of which it filled. To the right it reached the middle of the rectus abdominis muscle. To the left it filled the upper abdominal space and occupied completely the left epigastrium and hypochondrium. The percussion note was dull over the whole area and no shades of difference could be detected in its various parts. It did not move appreciably with respiration. It seemed to be firmly fixed to the posterior abdominal wall. The surface was roughly nodular. There was no pulsation.

*Urine examination:* Acid; specific gravity, 1012; sugar negative; albumen, a distinct ring; no casts. *Blood examination:* Red cells, 3,944,000; white cells, 6,200; hæmoglobin, 80 per cent.; polymorphonuclears, 50 per cent.; lymphocytes, 49.5 per cent. Wassermann reaction, strongly positive. No examination was made of the stomach contents.

*Diagnosis.*—A tentative diagnosis of retroperitoneal sarcoma was made and an exploratory operation was performed on November 24.

*Operation.*—A large angular incision was made, the vertical cut passing downward through the inner edge of the left rectus from the epigastrium to the umbilicus, and the lateral cut from the lower end of the vertical upward and backward to the tip of the twelfth rib. This gave a full exposure. The growth was found free from attachments to the transverse colon or to the right half of the stomach. It seemed to have pushed its way forward between the greater curvature of the stomach and the transverse colon. It was very nodular and cystic. It was covered in front by a thin layer of omentum in which very large veins coursed. Followed to the left it fused with the spleen. To the right it was free. Posteriorly it could be lifted from the aorta. At first it looked an impossible task to remove it; but after division of the omentum which covered it in front and opening the lesser sac and lifting up the stomach it was possible to separate it from all the anterior surface of the pancreas except about two inches of its tail. The left edge of the growth appeared to be jammed tightly between the tail of the pancreas and the spleen. The greater curvature of the stomach was also adherent to the growth over a small area. The tail of the pancreas and the splenic vessels were isolated and clamped, and a clamp was placed on the greater curvature of the stomach and the

growth removed with remarkably slight hemorrhage. A careful examination of the other abdominal organs revealed no abnormality. A drain was placed near the stump of the pancreas and the abdomen closed. Convalescence was unattended by any irritating discharges.

*After History.*—The patient returned to his work as a drayman six weeks after the operation and since that time has worked every day without fatigue. On October 15, 1917, I examined him carefully. There was no symptom of recurrence. He was sound and robust and weighed 157 pounds. *Blood count:* Red cells, 3,944,000; white cells, 6,200; polymorphonuclear neutrophils, 50 per cent.; lymphocytes, 49.5 per cent.; transitional forms, 0.5 per cent.; hæmoglobin, 80 per cent. *Urine:* Straw colored, acid, specific gravity 1012, distinct ring of albumen, no sugar, a few leucocytes, amorphous urates, a few clear epithelial cells. Wassermann reaction, strongly positive, 4+.

*Description of the Tumor.*—The specimen removed was as large as a Rugby football. It consisted of the tumor, of the tail of the pancreas, the spleen, and a part of the greater curvature of the stomach. Both spleen and pancreas were tightly spread over the left edge of the tumor. Neither organ seemed to be infiltrated. The stomach wall was infiltrated and the growth projected slightly into the lumen. The tumor was very irregular in outline and its surface was nodular. Numerous blood cysts bulged from its surface. Its blood supply appeared to be derived entirely from the splenic vessels.

Section of the tumor showed numerous cysts of a large size separated from one another by septa of considerable thickness. The cysts contained blood in various stages of disintegration. Its color was mainly of a deep maroon tint. There was no gross evidence of intracystic growths. The septa consisted for the most part of tissue of a yellowish-pink color and firm consistence in which were found numerous areas of blood extravasation also of a deep maroon color. These septa evidently represented the main part of the original tumor. The gross features are well represented in the plate (Fig. 15).

The microscopical characteristics are shown in Figs. 9-14.

The pathological interpretation of the tumor is entirely our own, but we feel a little hesitation in insisting on our view obstinately. I have submitted the slides to my friend and former colleague, Dr. Allen J. Smith, of the University of Pennsylvania, whose opinion is that it probably resembles a chordoma which has undergone a sarcomatous change.

NOTE.—Early in January, 1918, the patient was readmitted to hospital with numerous widespread recurrences of the growth in the abdominal cavity. No further operative treatment was justifiable.

If the gliomatous nature of this tumor is admitted it probably takes its origin from one of the sympathetic plexuses of the upper abdominal cavity, in this particular case the plexus splenicus. Tumors of large size have been found arising in the upper abdominal cavity from these plexuses and from the adrenal gland which on microscopical examination have shown ganglion cells, axones and dendrites (Adami).

We have not been able to find indubitable evidence of ganglion cells, although in one specimen an area was found in which several bipolar cells strongly resembling ganglion cells were clearly distinguished.

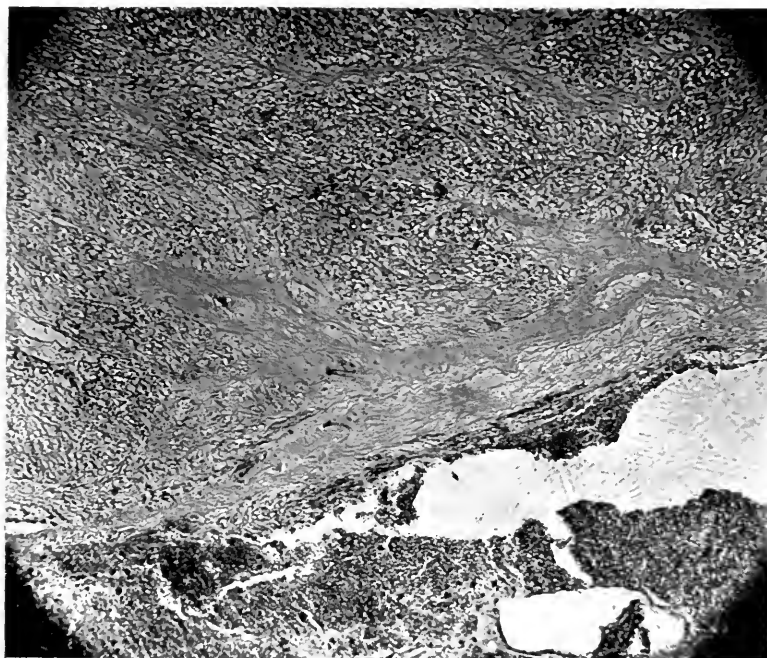


FIG. 9.—Shows a section taken through the wall of one of the blood clots in the tumor. It contains a portion of the clot. It will be seen that there is no epithelial lining to the blood space, nor is there any epithelium lining other cyst-like cavities containing gelatinous substance, which are found elsewhere in the tumor. The lighter portion of the slide shows collections of fine, faintly pink stained fibrillae which I interpret as neuroglia fibrils, since they do not take a connective-tissue stain with Van Gieson's fluid. The darker portions represent collections of glial cells.

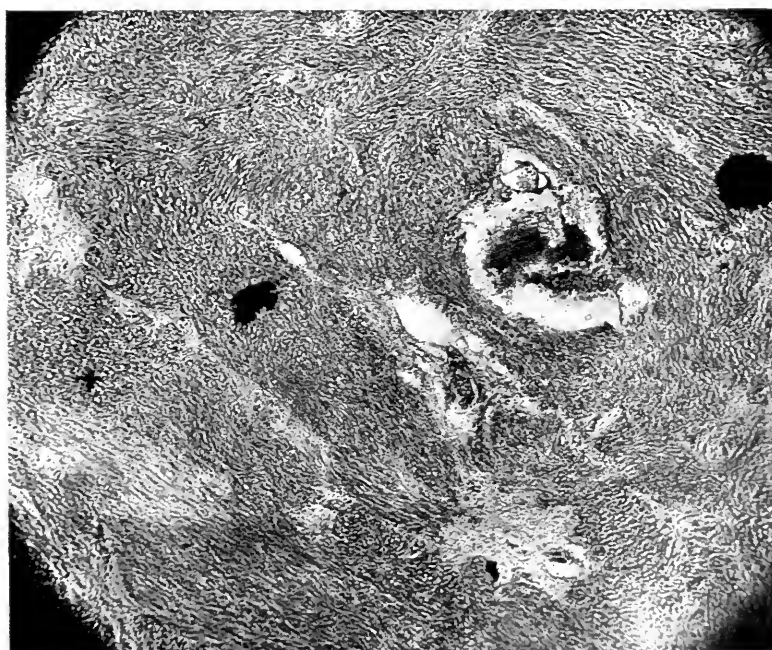


FIG. 10.—Shows another area of tissue, containing one small hemorrhage about the middle of the slide and several of the lightly stained collections of neuroglia fibrils. In the darker, more cellular portion of the section, some of the cells have a radial arrangement, suggestive of ependymal cells. Such an area, marked with a small cross, is shown in higher magnification in the following figure.



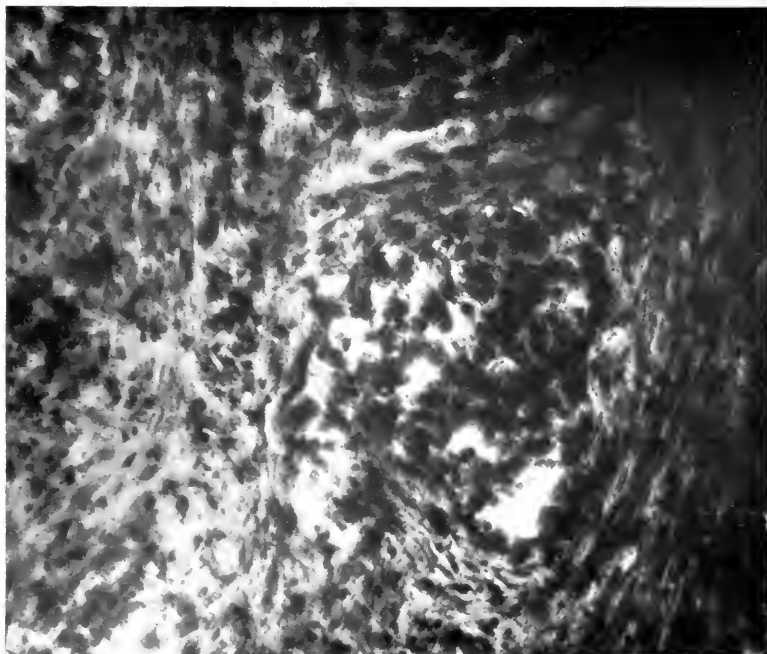


FIG. 11.—Higher power photograph of one of the radial collections of cells indicated in Fig. 10, and strongly suggestive of ependymal cells.



FIG. 12.—Another very low power photograph from the opposite end of the tumor, taken to emphasize the uniformity of its structure. Here again are light areas containing few cellular elements, and probably representing collections of neuroglia fibrils. In the more cellular portions are groups of round cells, some of them arranged in a radial manner, and many collections of spindle-shaped cells with indefinite outlines, of which higher-power pictures follow.



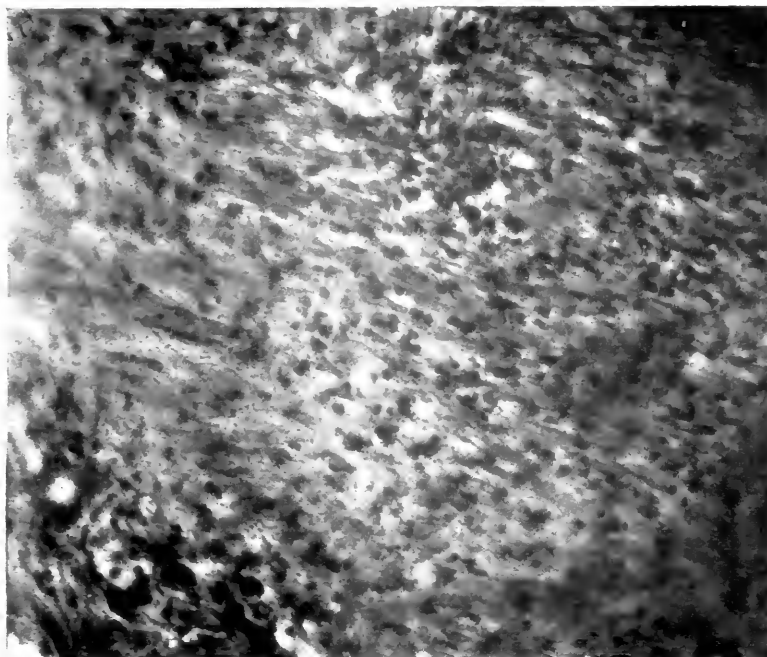


FIG. 13.—High power picture of a portion of the section just shown. These areas of round and spindle cells mixed together are very much like sarcoma and probably indicate sarcomatous change in the glioma.

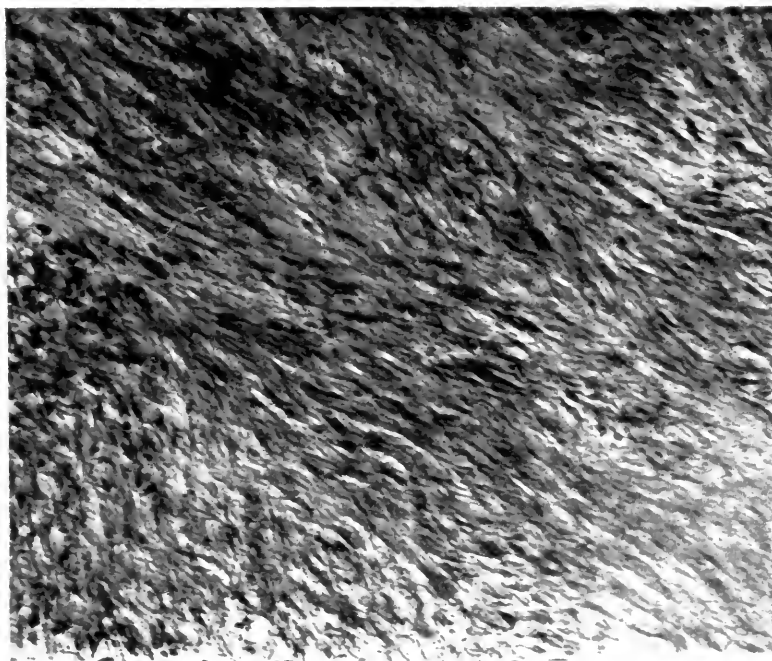


FIG. 14.—High-power photograph of another area from Fig. 12, showing a collection of indefinite spindle cells, very suggestive of sarcoma.

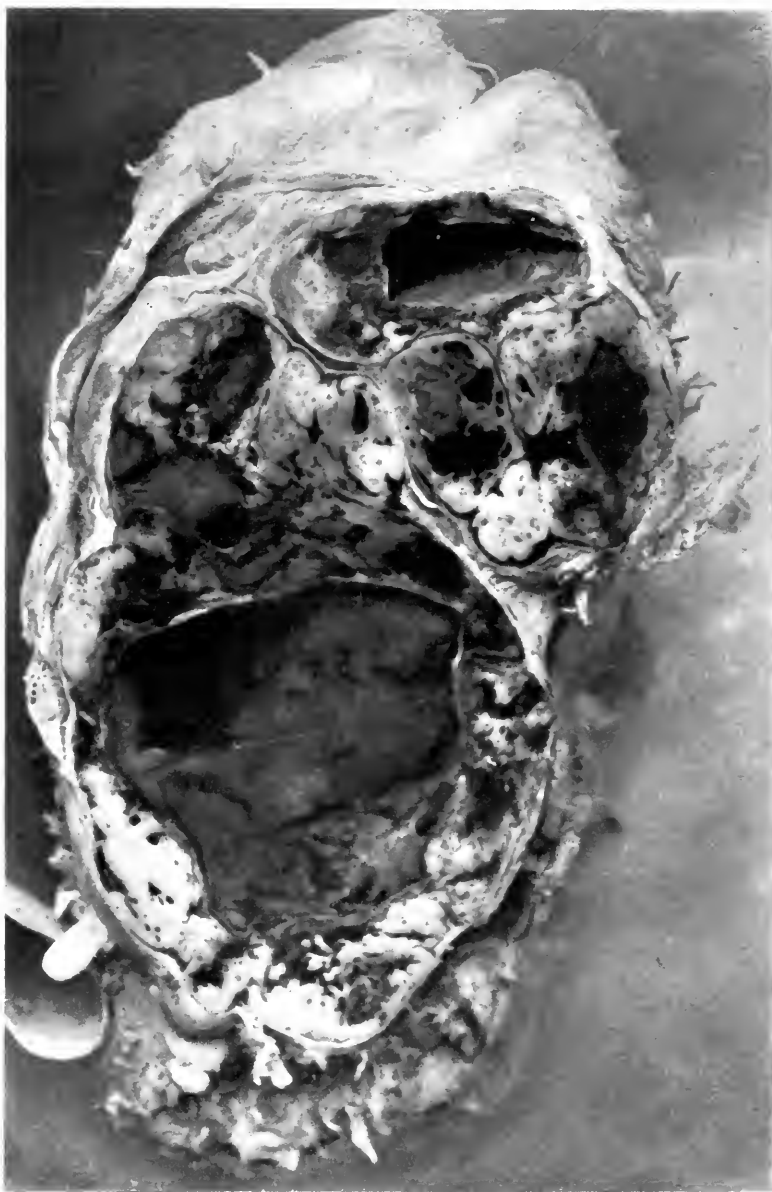


FIG. 15.—Section of the glioma of the upper abdominal region. The black areas represent blood cysts and blood extravasations. The white areas represent the intrinsic tissue of the tumor. Notice that it is mottled with small extravasations of blood.

## REPAIR OF COMPLETE RECTOVAGINAL LACERATIONS\*

BY IRVING S. HAYNES, M.D.  
OF NEW YORK

THE successful treatment of complete rectovaginal laceration is of such importance as to justify the publication of any procedure that makes such success more certain.

The entire absence from standard books on pelvic surgery of any operation for the repair of such extensive lesions is an added reason for placing the following report on record. The operation hereinafter described is one that I performed in January, 1916, for the repair of a total division of the rectovaginal septum from the cervix to and through the perineum.

The patient was an Italian woman, thirty-five years of age, who was brought to Harlem Hospital on January 12, 1916.

About two weeks before she had been delivered of a large child. During the process of extracting the baby she was completely torn as stated and the baby died.

The patient was mildly septic. Examination showed that the entire rectovaginal septum from the cervix to and including the perineum had been completely torn through in the middle line. The rectum and vagina constituted but a single canal that was filled with fæces and purulent discharge. With this exception the woman was strong and healthy. After a preparatory treatment of douches I performed the following operation:

The patient was anesthetized and placed in the lithotomy position. The common rectal and vaginal canal was opened by retractors. The edge of the torn rectovaginal septum was covered with healthy granulation tissue.

Beginning at the centre of the tear the rectal wall was separated from the vaginal, being careful to reach the compartment between the rectovaginal fascia and the rectum. The dissection was carefully carried out downward, separating the rectum and anal canal from their attachments. When the anal margin was reached the mucous membrane was severed from the skin. The attachments of the levator ani and external sphincter were noted. This mobilization of the rectum was carried upward to the level of the sacral promontory, several inches above the torn septum. The peritoneum was opened from the cul-de-sac upward as far as the above separation of the rectum. There was no hemorrhage. This wide mobilization of the rectum permitted the bowel to be easily drawn downward until the upper margin of the fistula was beyond the level of the anal skin.

Inasmuch as the external anal sphincter had contracted to about a third of its usual size, the anococcygeal body had to be split to within

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\* Read before the New York Surgical Society, February 13, 1918.

half an inch of the coccyx, in order to properly accommodate the rectum which was now rotated through 90 degrees and sutured into position with the fistulous border well beyond the surface of the skin. Chromic gut sutures were used for the sutures passing from the surface through the bowel. Plain gut sutures to attach the levator ani to the gut in its new position. A drain of rubber tissue was placed in the posterior angle of the wound. The excess of rectal tissue, about 3 inches, was trimmed off and the skin and mucous membrane sutured together. The peritoneum was attached to the downward displaced rectum.

The operation was completed by suturing together, with kangaroo tendon, the levatores ani and perineal body as in an extensive perineorrhaphy. Over these sutured parts the vaginal wall was closed. Healing was uneventful. The patient was discharged on February 10. She had bowel movements without difficulty.

In the following July she came to see me complaining of difficulty in defecation. This was due to a tight stenosis of the anus. The stricture was relieved by an incision directed posteriorly.

In November, 1916, she again reported to me, stating that she was two months pregnant and frightened nearly to death. She was kept under observation and delivered of a living child by Cæsarean section on June 5, 1917, at Harlem Hospital, by Doctor Cherry, Assistant Visiting Gynæcologist. During this operation the opportunity was taken to resect the tubes.

Over two years have now elapsed since the repair of the total rectovaginal laceration. She claims she is perfectly well. Naturally, after such extensive mobilization of the rectum, the nerve supply to this bowel must have been seriously damaged. While this must have been true, some sort of a reflex mechanism must have later been developed because the patient claims she knows when her bowels are going to move and she has no difficulty in controlling the movements, only she must not wait too long after the call comes. The bowel opening has contracted considerably, but she refuses to have it enlarged, saying it is all right.

I have not made a complete search of the literature, but from the library of our Academy of Medicine I have found no method described for the repair of such an extensive tear as I have related. None of the standard text-books make any reference to the condition, except Ashton, who advises how inoperable cases should be treated by douches, sitz-baths and a constipating diet.

Segond,<sup>1</sup> in 1895, and A. Palmer Dudley,<sup>2</sup> in 1902, described the method they had used for the treatment of a rectovaginal fistula just below the cervix. Their operations are identical and consisted in freeing the anterior wall of the rectum from the anus upward until above the level of the fistula, bringing down this anterior wall until the rectal part of the fistula was out-

<sup>1</sup> Segond: *Ann. de Gyn.*, Paris, 1895, vol. xliv, pp. 1-4.

<sup>2</sup> Dudley, A. Palmer: *Jour. A. M. A.*, 1902, vol. xxxix, pp. 185-190.

side of the anus, suturing the gut in this position, trimming off the excess of rectal tissue and finally closing the defect in the vagina. Both had perfect cures.

Ligueu,<sup>3</sup> in 1903, described an essentially similar method for the treatment of a high rectovaginal fistula, only, he approached the fistula through a transverse incision between the anus and vagina as for a perineorrhaphy. The work of these surgeons was unknown to me until I began looking up the subject for this paper, even if there is a slight similarity between their method and mine, I think I may fairly claim originality for the conception and execution of a successful method for the treatment of complete rectovaginal lacerations.

I would emphasize the following steps:

1. Begin the separation of the rectum from the vagina just above the levatores ani and in the space between the rectovaginal fascia and the rectum.
2. Separate the bowel downward through the anal canal and cut through the mucocutaneous junction. Carry the mobilization of the bowel upward high enough to obtain sufficient sound rectum so that the undamaged rectum may be drawn beyond the level of the skin.
3. Divide the anococcygeal tissues sufficiently far towards the coccyx to permit suturing the retracted sphincter ani externus in front of the rectum.
4. Rotate the rectum through 90 degrees and suture it in place, especially reforming the attachments of the levatores ani to the bowel. Trim off the excess of rectal tissue and suture the skin to the rectal mucosa. Drain the region behind the rectum.
5. Complete the operation by a perineorrhaphy.

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<sup>3</sup> Ligueu: Bull. et Mem. Soc. Chir. de Paris, 1903, vol. xxix, pp. 793.

## CANCER OF RECTUM\*

BY JEROME M. LYNCH, M.D.

OF NEW YORK

MEDICAL RESERVE CORPS U. S. A.

CANCER of the rectum and colon has increased one hundred per cent. in the past fifteen years according to the report of Vital Statistics of the Registration Area of the United States. Bloodgood has well said that in the life history of every malignant growth there has been a moment when it was surgically curable and the lesions under consideration offer no exception to this admirable axiom. To recognize and to seize upon this precious moment is no less than to control the life destinies of the affected individual.

*Results of Surgical Treatment.*—Of 491 cases studied we have operated upon 335. The hospital mortality was 16 per cent. Forty-one have lived one year; 45 two years; 33 three years; 22 four years; 26 five years and 17 six years.

Patients not replying to circular letter have been classified as dead when last heard from. As in all clinics situated in cosmopolitan centres where the population is in constant flux, it is impossible to follow a large number of the patients. Thus the statistics as above created are necessarily less favorable than if every case had been followed to date.

Whatever disability exists as results of operation does not interfere with livelihood gaining. One of our patients who was bankrupt when his rectum and sphincter were removed, and who leaks at times, now makes four trips to Europe and has earned over a million dollars since operation. We cannot overemphasize the plain fact that post-operative conditions, no matter how unfavorable as to function, do not interfere with the usefulness or economic independence of the patient.

Incontinence is a relative term. Its importance has been grossly exaggerated. As no horse is sound, so no human body is without defect, and even great defects are compensated for by the natural endowment of the individual to meet such obligations. It is simply a question of getting used to the discomforts of a colostomy or a leaking anus—a psychological phenomenon well worthy of consideration. Think of the innumerable women torn in childbirth who have been incontinent for a quarter of a century, yet who efficiently and without affront to their families perform their daily work. Because of this psychological element we strongly prefer to have a relatively incontinent normal anus rather than upon the abdomen. This, briefly, is the result of surgical therapeutics in our series.

What stronger argument could there be for discussing the diagnosis and the indications? These statistics show that rectal cancer operated upon even after great delay and by poor methods is not hopeless. If with these

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\* Read before the American Gastro-Enterological Assn., May, 1917.

limitations we get results, how important, therefore, is the early diagnosis and how promising the outlook for the future.

What have been the methods of study in this series of 491 cases? Of first importance is a flat contradiction of some still prevailing convictions, to wit: That the operation is hopeless; that the cancer patient is cachectic or has lost weight; that age is of importance; that pain is a prominent symptom and that a tumor can always be felt. The very occurrence of these symptoms spells inoperability.

What are the important symptoms from the modern standpoint in order of diagnostic and therapeutic importance?

First, constipation: This we believe to be the very first and earliest of all symptoms. It is undoubtedly protective in type, being perhaps the result of biologic reaction to the influence of the new-growth. There are, however, several hypotheses as to its origin depending upon the path of inhibitory

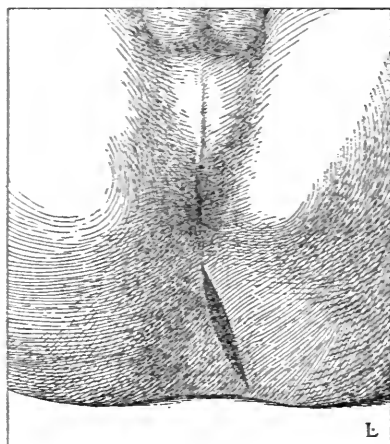


FIG. 1.—Shows where the first incision should be made when performing a perineal operation.

transmission rather than upon its origin or occurrence. Of the latter and of its protective nature there can be no doubt. Certainly it is not due to mechanical obstruction of the growth.

Second, stomach symptoms: We have repeatedly referred to these as esoteric as contrasted to hemorrhage and the like which are exoteric. Chronic indigestion, so frequent a sign of peripheral pathology, is just as significant of rectal cancer as of a chronic appendix.

Third, blood or bloody stools: This is usually the first exoteric sign. It can occur without ulceration, in which case it may be due to a blocking of the return circulation in the valveless veins leading to the liver. In any event hemorrhage so commonly associated with cancer (10 per cent. of our cases of 491 had been operated upon previously to our seeing them for hemorrhoids) is a frequent source of the blood. In a large proportion of the cases, however, it is due to ulceration.

Fourth, frequent and imperative desire to move the bowels followed by explosive discharges of gas, blood and mucus: This symptom is usually spoken of as the diarrhœa of cancer. It is not in reality a diarrhœa in that fæces are rarely passed.

These are the classical symptoms which every gastro-enterologist should know. Other symptoms occasionally noted are an indefinite pelvic discomfort and pain or tenderness over the cæcum which has been mistaken for right-sided pathology.

DIAGNOSIS.—A patient presenting any one of the above symptoms should have a rectal and proctoscopic examination as a matter of routine. In our series of 491 cases, 56 per cent. of the tumors were within 7.5 cm. of the anus; 69 per cent. were within 10 cm. of the anus, and 31 per cent. were oral to this. It is quite evident, therefore, that more than a half were within

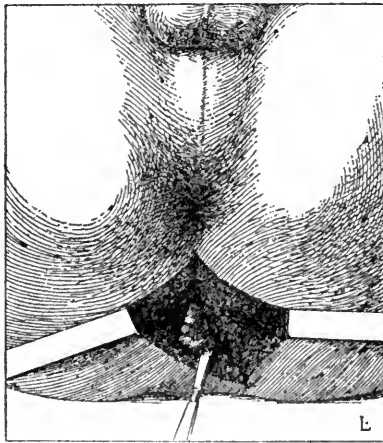


FIG. 2.—Illustrates the method of removing the coccyx.

reach of the finger, that two-thirds could have been diagnosed under anæsthesia by the finger, and that all except the sporadic cases in the colon could have been diagnosed by the proctoscope.

Duration of symptoms in this series was eight months. During this period many of the cardinal diagnostic symptoms already referred to had been present, so that at any time a diagnosis could have been made had the patient been examined.

Age.—In our series of 491 cases 4 per cent. were under thirty years of age; 7 per cent., thirty-five. According to the United States Bureau of Vital Statistics 5 per cent. of cases of rectal and colonic cancer were in children under nine years of age, 2.75 per cent. under nineteen years, proving that cancer is not confined to any age and that, while it occurs more frequently in middle life, still, for all, we must recognize the danger of placing too much importance on age.



## CANCER OF RECTUM

A word must be said regarding the pernicious habit of biopsy for diagnosis. At the Symposium on Inoperable Cancer of the New York Academy of Medicine, Dr. Robert Abbe remarked that in the treatment of carcinoma by radium, the biopsy wound itself was one of the last to heal and was very stubborn.

**TREATMENT.—Operability.**—In our series of 491 cases extending over a period of nineteen years, 153 were considered inoperable. Of great importance is the history of the advance of our technic and a more liberal understanding of the possibilities. From a study of unexpected results in many so-called inoperable cases we are convinced that even in the late cases, except when the peritoneum is involved, there is always a fighting

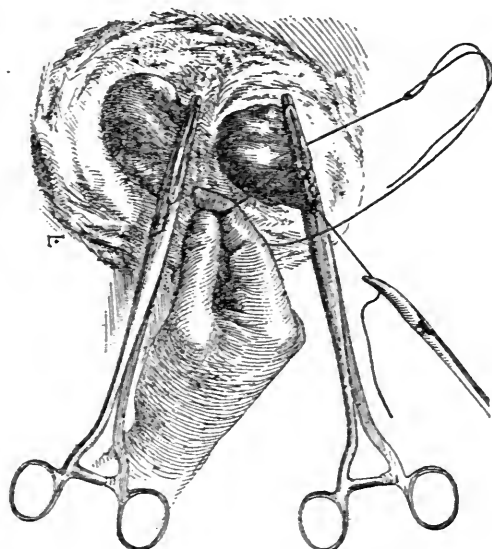


FIG. 3.—Illustrates the technic to be followed for dividing the bowel, when it is intended to leave the patient with a permanent colostomy and subsequently to remove the aboral portion of the sigmoid and the rectum.

chance. Of the 153 cases considered inoperable, none have been so classified because of the extent of involvement in the rectum itself.

Our operability for the total number is 60 per cent. This high percentage is due to the fact that Doctor Tuttle kept no record of inoperable cases. By operability is understood radical extirpation of the growth. In the past five years our operability has risen to 74 per cent. Let it be clearly understood that this refers to growths strictly localized in the rectum. As to the indications for radical treatment; when adjacent organs are involved our statistics show that we have often removed a part of the vagina, a part or whole of the prostate, seminal vesicles, urethra and uterus, several coils of intestine and part of the bladder. In many instances it is necessary to perform an exploratory laparotomy to determine whether the growth is operable.

*Choice of Operation.*—Operable cases: (1) Combined; (2) perineal; (3) abdominal.

We have performed the combined operation 111 times; in 36 of these cases it was performed in two stages. It is our operation of choice.

The perineal has been performed 102 times; the abdominal 20 times. Formerly we used the following operations now in disuse: Kraske, 20; modified bone flap, 32, and intrarectal, 18. When possible, for the psychical reasons already described, we always place the anus at the normal site. We prefer to perform the operation in one stage if it is possible, but, if necessary, we divide it into two stages.

The perineal operation is our operation of choice in very fat or in extremely debilitated people (Fig. 1). In all cases, as a matter of routine, we always remove the coccyx (Fig. 2). Preliminary colostomy is always done

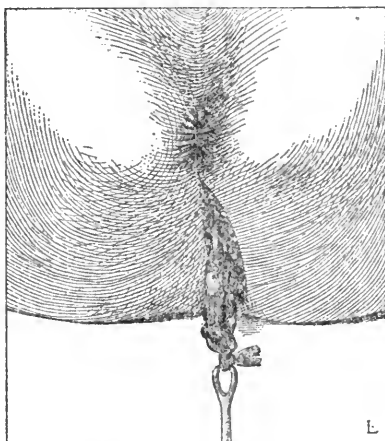


FIG. 4.—Illustrates the method of invaginating the proximal end of the aboral sigmoid and rectum.

when the growth is within 2 cm. of the anus, in order to prepare for the extensive removal *en bloc* necessitated by lymphatic involvement.

We have for some time abandoned rectal resection for the reason that in all of these cases the operation was followed by stricture. This is due to the presence of a terminal blood supply in the rectum rather than, as commonly supposed, to the absence of peritoneum. Exceptional work on dogs has been done by Barber which has confirmed us in this belief. It is the ischæmic rather than the peritoneal denudation that produces the stricture. It is axiomatic that the amount of scar tissue is in reverse ratio to the blood supply. This important contribution will form the basis of a subsequent paper.

*Palliative Operative Treatment.*—What can be done in this type of case is still of great importance. Until earlier diagnoses are made many cases will continue to fall in this class. If this paper served no other purpose than to convince the profession of the necessity of early colostomy in

inoperable carcinoma of the rectum it will have done some good. The fixed attitude toward colostomy is that it should be postponed until obstruction supervenes. This is certainly not in accord with the facts as we find them in 36 cases for cancer alone and in over one hundred for other conditions. It can be done, if necessary, under local anæsthetic.

What are the advantages of early colostomy in inoperable cancer as opposed to the supposed disadvantages? It reduces the inflammation, often converting an inoperable into an operable case. It obviates intestinal obstruction and its accompanying symptoms of pain, constant secretion and defecation, permits rest and sleep and insures recuperation. The patient renews his normal routine as to habits and diet. It stops hemorrhage. In short, it places the parts at surgical rest. If early it is without notable mortality; if late this rises to 40 or even 50 per cent.

*Local Cauterization.*—This is frequently of great value; it stops pain and limits secretion and odor. If frequently repeated it may keep a patient alive for many months.

Treatment by radio-active substances, fulguration and by biochemical derivatives is not here considered.

## CONCLUSIONS

1. We would urge that digital and proctoscopic examinations be made routine in all patients presenting gastric or intestinal symptoms. If this is adapted a great many cases will be diagnosed early and saved.

2. That all cancer cases should be referred to a surgeon, as he is best fitted to pass judgment as to whether they are suitable for operation or not.

3. If inoperable, colostomy should be performed as soon as possible, thereby saving much suffering and discomfort.

4. That no patient should be denied a radical operation until it is proved beyond doubt that it is not justifiable.

5. That our technic is now more perfect and consequently we are saving many cases which previously died from shock and peritonitis.

## CORRESPONDENCE

### SKIN ASEPSIS IN SURGERY

EDITOR ANNALS OF SURGERY:

PROBABLY there is no detail on which the ultimate success of a surgical operation is more dependent than the employment of an efficient, but non-irritant, antiseptic for the sterilization of the operator's hands and the skin of the patient, and the maintenance of the latter in an aseptic state until physiological repair has taken place. The object of this communication is to invite attention to some personal deductions derived from an extended experience, and to pay tribute to the chemical—perchloride of mercury—which has, in and out of season, stood the test of the diverse experiments, modes, and whims incidental to three decades of hospital practice.

I. Perchloride of Mercury is the most reliable and least irritant antiseptic that I have, so far, met with for the sterilization of my hands. The routine is as follows: The nails are trimmed, and hands and arms scrubbed in a running stream of warm water, with soap and nail brush. They are then thoroughly washed in hot formalin lotion (15 c.c. of 40 per cent. solution to litre of water). Next immersed for a few minutes in alcoholic mercurial solution (Hydrarg. Perch. 1; acid tartarici 5; water 200; and alcohol 800). And finally are washed in acid mercurial lotion (Hydrarg. Perch. 1; acid tartarici 5; water 2000). The latter is repeated, when necessary, during the operation, and the full preparation is gone through irrespective of the use of gloves.

II. It is the most potent and, at the same time, the least noxious chemical for the sterilization of the skin, and while its primary effects usually endure until the wound is healed, it rarely causes any subsequent irritation in or around the operative field, and is comparatively guiltless, as a causative factor, in the production of that disconcerting legacy—post-operative intestinal adhesions. During the past year I have had so many cases returning, who had been operated on during the iodine epoch, presenting symptoms of chronic intestinal obstruction, that I feel convinced that disinfection of the skin of the abdomen by tincture of iodine is a most dangerous procedure, and I regret to have to state that, in some of my cases, it has proved itself to be a veritable death trap. I have observed one particular variety of adhesion constant in these cases—one or more dense strands of omentum which glue or suspend the transverse colon to the anterior parietal wall, and, frequently, underlying these bands, one encounters an adherent conglomerate of distorted coils of small intestine, the undoing of which is often a most laborious and exhaustive undertaking; how peristalsis ever overcomes such obstacles and how the foodstuff pirouettes through such a maze, only tends

to prove that the human body is endowed with a most remarkable margin for error.

I find this parlous condition particularly frequent after gastric operations, and common after appendicitis (I do not refer to adhesions in distal segment of ileum), and it induces symptoms which may readily be mistaken for a recrudescence of gastric ulceration, or raise a doubt as to the efficacy of excision in relieving the syndrome of a diseased appendix. As a matter of fact the last state of these unfortunate persons is often much worse than the first, in that they usually have the pangs and paroxysms of obstruction tacked on to their previous aches.

Such being my experience, I found it incumbent to forego the convenience and simplicity of the iodine method in abdominal work and to revert to my old formula, viz.: Shaving and scrubbing the field with soap and water, then washing with alcoholic mercurial solution, next applying a large square of sterilized lint wrung out in warm aqueous mercurial lotion, and retaining same in position by sterilized wool and bandage, until the following day, when it is removed on the operating table, and a final wash with alcoholic mercurial solution is given before the dry towels are applied to isolate the part.

III. Perchloride of mercury fomentations are the ideal dressing for septic wounds in that they keep the surrounding skin in good tone, and free of intruders while the fight is raging within. This is a most important consideration, and has not received the attention which it deserves. There is no chemical of equivalent potency comparable to Hyd. Perch. in this respect, as it rarely produces any eczema or other irritation, and never gives rise to any symptoms of absorption. Also it may be apropos to mention the well-known, but commonly ignored fact, that the continuous application of heat is of immense service in assisting the natural processes in the elimination of infection. Hot "perchloride" fomentations (1 in 3000), wrung dry, used in conjunction with three or four hourly irrigations of wound with hot peroxide hydrogen lotion (60-120 c.c. to a litre) followed instantly by hot carbolic lotion (15 c.c. to litre) is the best treatment for any desperate infected wound that I know of—if combined with the ordinary rudiments of surgery—free dependent drainage, removal of foreign bodies (which obviously includes all dead material), absolute rest and continuous out-door fresh air.

IV. Hot "perchloride" fomentations applied hourly, except when patient is asleep, is the most effective and rapid method of curing a carbuncle in debilitated subjects, *e.g.*, diabetics and nephritics, and renders the use of a knife unnecessary. For years it had been my practice to excise the back of necks and large segments of the dorsal regions, etc., but the severity of the procedure, in such subjects, and the length of time it took for those huge wounds to heal up, ultimately switched me on to the above method—which I have found to be constant in certainty of cure, and in the prevention of recurrence in adjoining area.

## CORRESPONDENCE

V. In the disease, furunculus, very prevalent in subtropical regions, lavage of the whole infected area, three times a day, with aqueous mercurial lotion, and the application—four hourly—of hot “perchloride” fomentations to the suppurating boils, is specific in its action.

VI. In conclusion, while it may appear that I hold a brief for “peroxide carbolic” irrigation of wounds, and “perchloride” application to the skin, I wish it to be distinctly understood that I only advocate their use in weak solution, as there is nothing more insensate than to mortify the flesh by chemicals at any time, much less at the moment when its resistance is sorely handicapped by infective germs and their products. But I do maintain that for septic wounds I know of no treatment equal to the above one—that is if healthy bright red granulations, prompt disappearance of toxic symptoms, early—but not sudden—cessation of purulent discharge and rapid healing is the criterion of merit.

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## OPERATIVE TREATMENT OF FRACTURE OF THE SPINE UNCOMPLICATED BY CORD INJURY

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DURING the past few years, the profession has learned that fracture of the spine is a much more frequent injury than was at first supposed. Many of the cases do not give the cardinal symptoms, and it is only by the routine use of the X-ray in injuries of the back that we are learning to recognize them. Many of the cases of so-called "back strain," "railway spine," etc., in which the symptoms were considered to be largely functional, we now are agreed are caused by definite injury to the spinal column itself. A surprisingly large number of these are quite free from cord or nerve-root symptoms, and, in many, such symptoms are present to a slight degree, and disappear in the early days after the injury. A study of the old cases of fracture demonstrates that a large majority suffer a prolonged and permanent disability and that this disability is due to an interference with the function of the spinal column, and not with the cord, the meninges, or the nerve-roots. Since such a large number show this long and permanent disability, even with careful supportive treatment, and also since this disability is due, in part at least, to the interference with the weight-bearing function of the spinal column, it becomes a vital question whether these cases should not have the benefit of operative treatment, with the object of firmly fixing the spine at the site of fracture. The fixation of the spine by an internal splint, inserting the single graft in the spinous process, by the method of Albee, or by the double graft, on either side of the spinous processes, or by ankylosis, according to the method of Hibbs, are all well enough established to insure the result of a stiffened area. This has already been done by the writers in a number of cases, and the object of the study which has been made in the series here reported is to determine by a comparison of the results, in non-operative and operative cases, whether it is advisable to recommend the operative procedure in cases of fractured

spine, and if so, in which cases, and when. The available old cases of undoubted fracture have been looked up and their conditions studied. Both fresh and old cases have also been included in the series, and the comparative results of the study of the two classes was pursued with the object of determining the comparative data. The cases have been studied with reference to the types of injury to the spine, the period of partial or permanent disability, and the symptoms which accompany it, as well as the effect of the mechanical treatment by fixation and support.

The condition after operation in the old disabled cases has been included in the series, and from this study the attempt has been made to determine which type of injury is most liable to result in the very long or permanent disability, and in which cases, if in any, it is best to operate.

The prolonged disability in cases of fracture of the spine has been mentioned by many writers, but the treatment advocated has been conservative and mechanical in a very great majority.

In general, operation has been discouraged, although the discouraging outlook has been admitted, even with the use of apparatus.

E. P. Palmer suggested an insert of a graft after laminectomy over the area in which the laminae were removed, but this was after the first operation had been done, and was in a case which had presented nerve symptoms sufficiently pronounced to warrant operation for cord pressure.

P. W. Roberts, in a report of four cases, suggests that bone grafting may be used when support has been worn for a reasonable length of time without improvement and when all other treatment has failed, but the operation was not done on any of the cases reported.

Albee, in his "Bone Graft Surgery," states that bone graft is indicated in cases of fracture of the spine with persistent non-union and increasing deformity, but he reports no operated cases.

Sever, in his report of eleven cases, states that the repair is usually good in the lumbar region, and that the supporting function is generally good, even in spite of the kyphos, which may tend to increase, but adds that permanent disability, as far as laborious work goes, generally follows such an injury. It would seem, however, that such cases should be grouped among the partially disabled class, and not among the recoveries.

Hartwell, in his history of eleven cases of fracture without paraplegia, calls attention to the frequent failure of mechanical measures, and advocates operation by graft when pain is not relieved by plaster jackets or if there is an increasing knuckle.

The bad prognosis in most cases, as well as the severity of the early disability, led us to operate early on a few of the fresh cases. The permanent disability in some of the old cases, which had had, or were having at the time, mechanical treatment, led us to operate on some of them. The results on both of these were so encouraging that the cases have been gathered together for comparative study.

The cases in this series include only those which had no, or only



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temporary, nerve symptoms, and with which the repair of the spinal column alone was in question. No case has been considered in which the diagnosis could not be unquestionably confirmed by röntgenological findings, and many of the recent cases, with whom we were able to communicate, have had stereoscopic radiographs, in order to rule out every possible chance of error.

Twenty-seven cases of fracture have been studied, of these ten were of the dorsal, and seventeen of the lumbar spine, and of this total number, nine were operated upon. The character of the trauma varied greatly. Sixteen cases were injured by falling variable distances, from eight to sixty feet, but striking in the most part in a position to cause forcible forward flexion of the spine. Two were suddenly forced into a flexed position, three caused by falling embankments, one dragged by a freight car, one forced through a mangle, one caught between freight cars, one struck by a train, and in one injury not known. Disability, because of pain, was immediate in all, except the one in which the man was caught between freight cars, who felt some pain at the time, but after being extracted continued with his work for about twenty minutes, when he pulled a switch, felt sudden pain in back, and fell unconscious. Another recovered sufficiently after two weeks of recumbency and two weeks of rest to work for three months, when pain returned, but was able to work for two months, when pain became so severe as to cause complete disability. Severe local pain and tenderness were constant factors. Pain referred down one or both thighs was frequent, and occurred in a large proportion of the lumbar fractures, while in those of the dorsal the pain seemed more commonly to be local. Tenderness over the point of fracture was found in every case, and the symptoms were all largely relieved by recumbency.

The presence of deformity is practically constant; kyphos or dis-alignment were found in all, kyphosis being the predominating deformity. The motions of the spine were limited and attended by muscle spasm and pain, as would be expected, except in a few, in which there was abnormal mobility at the site of fracture. Hip motions were, as a rule, free, with the exception of those which caused motion of the pelvis, and thereby of the spine, and caused pain either locally or referred down the thighs. This was true to a certain extent in both dorsal and lumbar fractures, but was more frequent and more severe in those in which the lumbar spine was involved.

Twenty-two of the cases were treated by recumbency and support. The time of recumbency of fifteen was less than one month, and the additional treatment by support and fixation was from three months to four years or more. A second, two years and ten months after the injury, could do light work only, and the motions of the back were very much limited. A third, in which ten years have elapsed since injury, has been able to return to his former occupation because it was not laborious. He had sufficient pain in his back to cause him, as he says, "to feel it," and heavy lifting is impossible. A fourth, two years and ten months since injury, is able to do light work, but only a portion of the time. Any occupation which necessi-

tates bending his back causes disability and pain. He is not a skilled workman, and has been unable to secure suitable work. A fifth, in which the fracture was a complete crush of the body, with some dis-alignment, was disabled for six months. One year following the injury he was working as a laborer. His back motions were limited, but the functional result seemed very good. It is now eight years since the injury, and he has had no return of symptoms. A sixth, in which there was evidently an impaction of the transverse process of the first lumbar with the twelfth dorsal, has returned to his former occupation, and is free from symptoms. It is now nine years since the injury, but unfortunately the exact length of his disability could not be determined.

Of the cases of the dorsal fracture, one, a crushed fracture of the bodies and of the laminae of the ninth or tenth dorsal, with marked dis-alignment of the fragments, is now wearing a leather jacket during the day, two years since the injury. His occupation has been changed to one necessitating less physical strain and less income. He is never free from pain at the site of the old fracture, and the motions of his back are very much limited. A second, a crush of the twelfth dorsal with marked dis-alignment, was still totally disabled by pain one year after injury, but now has unfortunately disappeared, and the present condition is not known. A third, a lateral crush with dis-alignment, two and a half years after injury has a fair amount of motion, but complains of pain and weakness of the back. Change of occupation was necessary. A fourth now wears a leather jacket a portion of the time, six years after injury. He returned to his former occupation after four years of practically complete disability. A fifth, five years after injury, has considerable pain in the back. All back motions are very much limited by pain and muscle spasm. She has been able to do light work for the past two years, but for the first three years was totally disabled. A sixth, a crush of the body of the twelfth dorsal with fracture of the lamina, is wearing support at the present time. It is six months since the time of injury, and he is unable to do any work because of back pain. This case was complicated by the fracture of the surgical neck of the humerus.

Nine cases have been treated by a bone graft, inlaid in the split spinous processes, extending two vertebrae above and two below the site of fracture. These cases were kept recumbent in a plaster shell or jacket for two months after operation. Of these five had had mechanical treatment and were still disabled. The remaining four were operated on in the early stages (within eight weeks) and can be grouped as fresh cases or cases untreated by mechanical measures. These cases, however, were all treated by recumbency or by support during the interval preceding the operation.

It is easily seen that the cases which have had the usual mechanical treatment have shown, in general, a prolonged disability. A comparison of the cases treated by mechanical means only, and those by operation shows the following.

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Of this series of twenty-seven cases twenty-two received mechanical treatment by recumbency and support. Of this twenty-two, four recovered, eighteen showed persistent partial disability. By recovery is indicated freedom from pain, ability to return to same or similar occupation. One of these four (Case XVII) is placed in this group, although the patient has taken a lighter form of occupation and still wears support a part of the time, but is free from pain, and is satisfied with his condition. The remaining eighteen show partial recovery, indicated by continuance of pain and inability to return to the usual or to like occupation. The time over which this period extended varied from four months to four years or more.

Of these, Case II was disabled at the end of four months, but disappeared. One (Case XXVII), still totally disabled at the end of five months, was operated upon, and one (Case XIII), still disabled at the end of six months, has since disappeared. With the remainder, the disability was known to have extended over a period of at least one year.

Of the nine cases operated upon, three were old fractures, which had shown only partial recovery. Since operation these three are free from the pain and disability which had existed before, and the patients are able to take up their occupations. These three (Cases XXIII, XXIV, XXVII) are included in the list of partial recoveries by the mechanical treatment, and were operated upon only after failure to obtain relief by this means.

Six of the operated cases were recent fractures. The earliest (Case XXV) was operated seventeen days after injury. The patient removed the support on his own responsibility in eight weeks, and returned to work three months after operation, and called himself well. One (Case XXII) is put in this group operated upon three months after injury, at which time the patient was completely disabled, and had an increasing knuckle. Six months after operation he was working full time as a lineman. One other (Case XXVII) returned to work at the end of five months and was comfortable. Two are more recent, eleven months or under since operation, are free from pain, and are active but not working. The last (Case XIX) is too recent for statistical value.

Thus for comparison of twenty-two cases treated by mechanical support, four show recovery, with eighteen partially disabled. Of nine cases operated upon, three were of old fractures, six were fresh, all of which show recovery, the time varying from three to six months. One has not yet had the test of work, but is active and free from pain.

It is fair to state that several of the twenty-two cases did not receive thorough or prolonged mechanical treatment, but, on the other hand, many of the cases showing the same kind of injury and having the most thorough treatment resulted in the same persistent partial disability.

As in any form of surgical procedure and particularly in those in which various forms of treatment may be used, it is very important to choose the right cases of fracture for bone grafting. Naturally, it is far too early to be very positive in this matter, but it seems to us that even with the limited

number of cases which have been operated upon, certain broad rules may be laid down. As cases come under observation, they can usually be classed as early and late. The early ones being those seen within a few days or hours after injury, while the late cases, as a rule, present themselves only after some months, or else have been under continued treatment and still present disability.

In the early cases it seems probable that any of the following conditions, in the absence of contra-indications, may be sufficient cause for grafting.

1. Abnormal mobility, either lateral or anteroposterior, at the point of fracture.

2. Increasing deformity.

3. Extensive fracture of the body or any fracture of the laminæ as shown by X-ray, even in the absence of either of the two other signs.

Grafting should not be performed for two or three weeks after injury in order to allow the hemorrhage to subside. It should not be done in fractures where there is a probability of crushed cord or any other extensive neurological lesion; it may, however, be done in cases where mild neurological symptoms have been present but are subsiding. Naturally, all general considerations, such as general condition, age, pulmonary disease, etc., should be taken into account, as in any major surgical operation.

Our general scheme in such early cases is, after studying the case and getting all the necessary data during the first few days after injury, to determine for or against operation. If a grafting operation is to be decided upon the patient is kept recumbent in a plaster jacket until the time of operation.

The old cases are usually seen months or even years after injury, and in them the problem is somewhat different. In these cases the patient's inability to work is the point about which the treatment hinges, and we feel that this is the most important indication for operation. Thus we have our indication in old cases for grafting as follows:

Inability to work: (a) From persistent pain at the point of injury; (b) persistent referred pain; (c) definite weakness of the back, with or without increasing deformity.

We do not feel justified in urging operation in old cases which do not show any of these symptoms. It is probable, however, that old cases with this train of symptoms will show one or more of the reasons for operation mentioned in connection with fresh fractures. If a late case has not had proper treatment, and the amount of disability and bone injury is not great, fixation in plaster or by means of a leather jacket may be advisable for some months before deciding on fixation by means of a graft. The contra-indications for grafting are essentially the same as those for fresh fractures.

*Technic.*—Little need be said in reference to the technic. The operation for fixation of the spine is well established as an operative procedure, and in these cases the usual form of the interspinous process graft was followed. It is advisable to have the groove in the spinous process deep, so as to give a

large surface of bone for the inlay. The inlay itself should be strong. It is important the ends of the graft should lie in the spinous process and not project into the interspinous space. It is also important to so place the patient on the operating table, that the back is in a position free from strain. No attempt has been made in any of the cases to correct the position or diminish the knuckle. In the graft of the fifth lumbar vertebra the method of splitting the sacral part of the inlay was used; the two upper sacral spines were denuded on their lateral aspect, the lower part of the inlay was split by a saw cut which was placed over the sacral spines, so that one portion was on either side, a necessary procedure, as the sacral spines are too thin and too shallow to admit of splitting. This method of spinal fixation by the internal splint is not as satisfactory in the lumbosacral junction as in the lumbar and dorsolumbar spine, for the fifth lumbar spine lies so deeply, and the junction between the fifth lumbosacral makes so sharp an angle, that it is difficult to lay a well fitting and strong graft on account of this combined depth and sharp angle. Also for the reason that the spine of the fifth lumbar vertebra is very apt to be small or even rudimentary, and does not afford a sufficiently large area to insert the graft in a satisfactory manner. The patients are all kept recumbent for two months in a plaster bed or plaster jacket, previously prepared, and a plaster is worn for the next four months of ambulatory treatment.

#### CONCLUSIONS

The evidence from the study of the foregoing cases is strongly in favor of early operative action. A large percentage of the cases which could be followed showed partial and even complete disability for years after the injury, many of which had prolonged mechanical treatment by fixation and support. It would seem, also, that the continuance of the mechanical support after a few months does not materially influence the result, but was of value in giving added comfort while wearing such support. This fact alone, viz., the failure of mechanical treatment, would seem to warrant active radical measures, provided the operative methods give reasonable assurance of benefit, and provided the indications for operation could be formulated. On the other hand, the results of early operative treatment, in the cases which have been watched, although not large in number, would seem to definitely indicate that early operation is a measure to be advocated in a very large number of cases. From a study of the foregoing, the writers suggest operation in the cases which show the following conditions:

1. Fresh fracture: (a) Crushed fracture of the bodies of one or more vertebræ associated with dis-alignment of fragments, particularly with involvement of any part of the laminae; (b) fracture of the fifth lumbar, of any part, but particularly with involvement of the laminae; (c) fracture of body showing increasing knuckle, abnormal mobility at point of fracture, or complicated with rupture of the supra- or interspinous ligaments.

2. Old fracture cases which show the persistent disability, as evidenced by inability to work, accompanied by continuance of pain, local or referred,

and with general back weakness, operation is advocated. Operation in the decade between fifty and sixty does not seem to be contra-indicated. The social position may at times have influence in directing for or against operation, for when the most rigid early care can be given, much more might be expected from early fixation treatment. Freedom from pain, however, in the early weeks of recumbent and fixation treatment, may be misleading, for it is possible, that even with the relief of all symptoms during the period of recumbency, the pain may return and cause disability when the patient becomes ambulatory and begins to use the spinal column.

One question has not been decided, viz., the extreme degree of and the persistence of the disability with simple crushed fracture of the body of the vertebra. It is possible that this may in part be due to the loosening of the anterior ligament or to the loosening of the intervertebral discs from the vertebral surface, with a rupture of the capsular ligament, and failure to firmly unite again. This seems plausible, for many of the long persistent symptoms are suggestive of a movable segment of the column. On the other hand, a very severe injury and perhaps extensive crush may result in a quicker and more complete recovery than in some of the apparently lesser ones.

#### RECORD OF INDIVIDUAL CASES

**CASE I.**—Patient aged thirty-six; occupation, housewife. Complaint, *weakness in back*. Duration two years and eight months, following automobile accident in which patient was thrown from machine, landing on back. Back is weak, tires easily after any exertion necessitating lifting or bending of back.

*Physical Examination.*—Has marked dis-alignment of spinous process of second lumbar vertebra; no abnormal mobility at point of fracture; well-defined kyphosis at second lumbar vertebra, all motions of spine guarded. No muscle spasm present; straight leg raising causes some discomfort at site of fracture.

*X-ray Examination.*—Lateral crushed fracture of second lumbar with chipping off of lumbar border of first lumbar.

*Treatment.*—Was recumbent for a short time immediately following injury; wheel chair for four months, and patient unable to stand, because of weakness and back pain. This was followed by walking on crutches for three months. Did absolutely no work for following year and three months. Back support worn for about three months in all.

*Result.*—It is now two years and eight months since the injury. The motions of the back are limited but not painful unless repeated a number of times. A distinct kyphosis is present. But weakness is so marked that she is able to do only very light housework.

**CASE II.**—Patient aged twenty-three; occupation, laborer. Complaint, *severe back pain*. Caught under falling embankment.

*Physical Examination.*—All motions of spine are limited, muscle spasm is marked, tenderness and knuckle in mid-lumbar region. Straight leg raising and thigh flexion on the right cause pain.

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*X-ray Examination.*—Crushed fracture of third lumbar. Osseous shadows in intervertebral line. No dis-alignment.

*Treatment.*—Recumbent three weeks, support four months.

*Result.*—Four months later well-defined kyphosis in lumbar region. The jacket was removed and his condition was only fair. At this time he was unable to return to work. Unfortunately he was not seen again.

CASE III.—Patient aged fifty-seven; occupation, carpenter. Complaint, *severe back pain*. Fell from scaffolding a distance of about twenty feet from ground.

*Physical Examination.*—Motions of the spine are limited. Tenderness and a well-defined knuckle are found in the region of the tenth dorsal and first and second lumbar vertebræ.

*X-ray Examination.*—Crushed fracture of the body of the first and second lumbar.

*Treatment.*—Jacket. Recumbency for one month.

*End-results.*—One year after injury walks very well. Wears leather jacket all the time except at night. Three years later: Complains of weakness of back, all motions limited. Can do no heavy lifting because of pain. Has changed occupation to one necessitating less physical strain, especially back bending and lifting.

CASE IV.—Patient aged forty-nine; occupation, brakeman. Dragged five car lengths by a freight car.

*Physical Examination.*—Swelling and tenderness over the first and second lumbar and decided limitation of all motions of back by pain. The spines of the eleventh and twelfth dorsal and first lumbar much more prominent than normal.

*X-ray Examination.*—Fracture of the second lumbar with possible fracture of spinous process of same.

*Treatment.*—Plaster eight weeks.

*Result.*—Ten years since injury. He has returned to his former occupation, which fortunately is not heavy work. A dull ache is present constantly in the back and is intensified by straining or lifting.

CASE V.—Patient aged twenty-seven, occupation, laborer. Fell about thirty feet in sitting position.

*Physical Examination.*—Pain over low lumbar region and sacrum. All motions of back are limited. Straight leg raising, both right and left, is painful. Other motions of hip are free.

*X-ray Examination.*—Marked lateral crush with rotation and dis-alignment of second lumbar vertebra.

*Treatment.*—Binder and strapping followed by a plaster jacket for a short time.

*Result.*—One year later: Did not work for six months. Working as a laborer now. Back a little stiff, but functionally very good. Eight years later: Working as a laborer, no symptoms.

CASE VI.—Patient aged thirty-two; occupation, farmer. Complaint, *pain in back*. Caught under door casing while riding through doorway on a wagon. The disability was immediate because of severe back pain.

*Physical Examination.*—Ecchymosis, tenderness and marked depres-

sion of spinous process of the eleventh dorsal vertebra. All motions of the spine are guarded because of muscle spasm and pain.

*X-ray Examination.*—Fracture of transverse process of the first lumbar with impaction into twelfth dorsal, obliteration of space between twelfth dorsal and the first lumbar.

*Treatment.*—Recumbent for a short time in a plaster jacket.

*Result.*—One year later walks well; lateral bending slightly limited to the left. Eight years later feels perfectly well. Has returned to former occupation.

CASE VII.—Patient aged twenty-eight; occupation, operator. Complaint, *pain in low back, inability to work*. Three years ago patient jumped four stories from burning building. Severe pain and back weakness, aggravated by standing for any length of time or bending back. Back feels stiff.

*Physical Examination.*—Marked kyphosis beginning at tenth dorsal and extending to first lumbar. Increased mobility at point of deformity. Flexion and lateral bending are fairly free. Backward bending very much limited.

*X-ray Examination.*—Crushed fracture of second lumbar.

*Treatment.*—Short recumbency and fixation with plaster jacket for eight months following.

*Result.*—Continued disability at last report.

CASE VIII.—Patient aged twenty-five; occupation, engineer. Complaint, *low back pain, local, and referred to lower abdomen and leg. Back weakness, inability to work*. Caught under falling embankment. Disability complete from beginning because of pain.

*Physical Examination.*—All motions of spine limited by pain.

*Treatment.*—Plaster jacket two years; leather jacket two years.

*Result.*—Pain on motion persisted for years. Recovery was complete in five years for light and possibly for heavy work. At present work, sedentary, patient well and comfortable.

CASE IX.—Patient aged forty; occupation, laborer. Complaint, *pain in lower dorsal region. Inability to work because of it*. Duration four years and seven months. Four years and seven months ago fell from third-story window. He was immediately disabled because of back pain. Constant pain in low dorsal region has persisted. It is worse when stooping, lifting or turning in bed. Has not been able to work, although it has been attempted several times since injury.

*Physical Examination.*—Distinct kyphosis in low dorsal region. All motions of back very much limited by pain. Straight leg raising limited on both sides but more so on left. Forced flexion of thigh on abdomen, especially left, very painful.

*X-ray Examination.*—Crushed fracture of the first lumbar vertebra.

*Treatment.*—Back strapping and thirteen days recumbency at the time of injury.

*Result.*—Total disability at present time.

CASE X.—Patient aged thirty; occupation, laborer. Complaint, *pain in lumbar region for past five years*. Five years ago, while working as laborer was caught under falling embankment. Disability was im-



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mediate. Pain on lifting or stooping so severe that it is disabling if continued for any length of time. The pain is not referred.

*Physical Examination.*—Small kyphosis at first lumbar vertebra. Motions of back fairly free. Very marked abnormal mobility at point of deformity.

*X-ray Examination.*—Crushed fracture of first lumbar.

*Treatment.*—In bed for five months without fixation.

*Result.*—Was completely disabled for three years. Two years ago he began light work which he has continued to do a part of the time with more or less discomfort.

CASE XI.—Patient aged thirty-five; occupation, fireman. Complaint, *pain in back and referred, and feeling as though back was giving way*. He fell down a twenty-foot embankment. Disability was immediate because of pain localized in low back.

*Physical Examination.*—Tender prominence of spine of the tenth, eleventh, and twelfth dorsal and first lumbar vertebrae. Some muscle spasm is present. All motions of the back are restricted. Inability to work on account of pain. Is working at occupation requiring no strain (flagman).

*X-ray Examination.*—Crush of body of eleventh dorsal vertebra.

*Treatment.*—Recumbent for two weeks and after one month mechanical support, which is still worn, four years after injury.

CASE XII.—Patient aged forty; occupation, laborer. Complaint, *disabling pain in back*. Patient was brought to hospital in an intoxicated condition. Complained of indefinite pain in back.

*Physical Examination.*—Swelling and slight ecchymosis over low dorsal region. Tenderness marked, all motions of the spine limited.

*X-ray Examination.*—Lateral crush and dis-alignment of the tenth dorsal with preservation of intravertebral spaces.

*Treatment.*—Recumbent one month.

*Result.*—Disappeared.

CASE XIII.—Patient aged thirty-six; occupation, laborer. Fell twenty feet, landing on feet. Disability was immediate. Back pain was very severe and intensified by motion.

*Physical Examination.*—Seeming depression of the spine of the twelfth dorsal vertebra. A large ecchymosis in this region. Tenderness marked and all motions of spine guarded.

*X-ray Examination.*—Fracture of body of twelfth dorsal vertebra with dis-alignment.

*Treatment.*—Plaster jacket and rest in bed for a month.

*Result.*—Pain still present seven months after injury in dorso-lumbar region. Motions of the back were limited and painful. Leather jacket was advised but the patient did not return and was lost sight of.

CASE XIV.—Patient aged thirty-four; occupation, brakeman. Struck by train and knocked down, but after a short time he walked to his home, which was a short distance away. Pain in dorsal region was constant and intensified by any movements of the back.

*Physical Examination.*—A distinct kyphosis present, extending from

the eighth to the tenth dorsal vertebræ. All motions of the back are limited by pain. Tenderness over the deformity marked.

*X-ray Examination.*—Compression fracture of the bodies and laminæ of the ninth and tenth dorsal vertebræ with considerable displacement.

*Treatment.*—Recumbent two months, followed by fixation with plaster casts and leather jacket.

*Result.*—At present time, two years since injury, still wearing jacket during day. Has had to take up lighter work. Pain is constant. He can do no lifting or anything that requires bending the back; marked kyphos at ninth and tenth dorsal vertebræ; marked tenderness over the deformity, and limitation of all motions of the spine. Practically almost entire incapacity.

CASE XV.—Patient aged thirty-eight; occupation, lineman. Complaint, *dull aching pain and tenderness in back*. Fell twenty-five feet from a pole eight months ago, at which time patient fractured surgical neck of right humerus and injured back. Considerable pain was present in back at time, but it was not treated. Pain persisted, and two months later fracture was diagnosed by X-ray, and plaster jacket applied.

*X-ray Examination.*—Crushed fracture of twelfth dorsal vertebra.

*Treatment.*—After two months plaster jacket support still worn.

*Result.*—It is now eight months since injury. Patient is wearing jacket and unable to work. All motions are limited by pain; a distinct kyphos is present in the low dorsal region. Pain on standing if jacket is not worn.

CASE XVI.—Patient aged forty-seven; occupation, nurse. Complaint, *pain in low dorsal region*. Thrown from automobile. Disability was immediate because of pain in back, inability to stand or sit.

*Physical Examination.*—Increased prominence of the spine of the ninth dorsal vertebra. All motions limited, very marked pain in back and referred to abdomen.

*X-ray Examination.*—Crush of ninth dorsal vertebra.

*Treatment.*—Recumbent in plaster jacket for eight weeks, and mechanical support for four years.

*Result.*—At present time, five years after injury, still has considerable pain in back. All back motions are restricted and painful and patient has been forced to take up lighter work, and is still obliged to wear light support.

CASE XVII.—Patient aged forty-five; occupation, brakeman. Complaint, *pain in back*. Fell while climbing from tender of engine to first car. Was unconscious for a time, but when consciousness was regained he could not walk because of pain in back.

*Physical Examination.*—A rounded kyphos extends from the twelfth dorsal vertebra to the first lumbar. All motions of the spine somewhat restricted.

*X-ray Examination.*—Crushed fracture of the body of the twelfth dorsal vertebra.

*Treatment.*—Recumbency, followed by plaster jacket for several months, followed by a leather jacket which is being worn a part of

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the time at present, six years after the injury. After four years of disability he returned to a similar but lighter work.

CASE XVIII.—Patient aged forty-nine, occupation, laborer. Injured by being crushed between top of elevator and roof of shaft.

*Physical Examination.*—Obliteration of vertebral sulcus; abnormal mobility at point of fracture and kyphos at the twelfth dorsal vertebra. Pain not prominent feature.

*X-ray Examination.*—Crushed fracture of twelfth dorsal vertebra.

*Treatment.*—Plaster and recumbency. Still in recumbent treatment.

CASE XIX.—Patient aged twenty; occupation, iron worker. Complaint, fell sixty feet, unconscious several hours. Severe pain in low dorsal region extending through the abdomen, aggravated by any motion of back, or coughing, or sneezing.

*Physical Examination.*—Definite kyphos at eleventh dorsal, and obliteration of the vertebral sulcus. No dis-alignment of spinous processes or abnormal mobility at point of fracture. All motions of spine limited by pain. Referred abdominal pain. Straight leg raising is limited equally on both sides.

*X-ray Examination.*—Crushed fracture of eleventh dorsal vertebra.

*Treatment.*—Short recumbency and fixation with plaster jacket followed by bone graft operation.

*Result.*—This case is too recent a case to give result at this time, but at present (five months) he is active and free from pain.

CASE XX.—Patient aged twenty-nine; occupation, housewife. Complaint, fell off roof, striking on back on ground about eight feet below. Pain was severe, but could walk into house. Pain on any motion of jarring was much more severe upon entrance to hospital a few hours later than immediately after accident.

*Physical Examination.*—Knuckle in low dorsal region. There is some dis-alignment of spinous process of the eleventh dorsal vertebra. No abnormal mobility at point of fracture can be demonstrated. The normal vertebral sulcus has disappeared. Hip motions and straight leg raising were painful; very marked referred abdominal pain.

*X-ray Examination.*—Crushed fracture eleventh dorsal.

*Treatment.*—Recumbency in plaster for one month. Bone graft, recumbent two months.

*Result.*—Now, eight months since the operation, the patient is active, doing own housework, no pain nor disability. Is still wearing support occasionally as precaution.

CASE XXI.—Patient aged twenty-seven; occupation, laborer. Complaint, *pain in lumbar region for six weeks duration, aggravated by walking, lifting, or bending.* Fell fifteen feet six weeks ago, landing on back on concrete floor. Disability was immediate because of pain which was entirely local.

*Physical Examination.*—Flexion and extension of spine limited, but lateral bending is fairly free. There is a well-defined kyphosis in the region of the first lumbar vertebra.

*X-ray Examination.*—Lateral crush and dis-alignment of the first lumbar vertebra.

*Treatment.*—Recumbent for three weeks on Bradford frame, followed by bone graft and two months recumbency in jacket, and later ambulatory with jacket.

*Result.*—Seven months following operation is active with perfect comfort. A plaster jacket is being worn at present.

CASE XXII.—Patient aged twenty-eight; occupation, lineman. Complaint, *pain in lumbar region radiating to left leg*. Six weeks ago fell thirty feet, striking on back. Disability was immediate because of back pain. Remained recumbent in hospital one week and was discharged, still complaining somewhat of pain. Three weeks following discharge, returned, seeking relief from pain which patient says is growing worse. He is unable to remain recumbent on back, but can rest comfortably on side for a time. Pain is relieved somewhat by walking.

*Physical Examination.*—There is a marked kyphosis over the third and fourth and fifth lumbar vertebræ. Muscle spasm present. All motions of spine very much limited. Hyperextension and straight leg raising of left leg cause severe pain which radiates down left thigh.

*X-ray Examination.*—Crushed fracture of second lumbar vertebra.

*Treatment.*—Bone graft, three months following injury.

*Result.*—Relief of pain was almost immediate following operation. Six months later he had returned to work as a lineman. Support was worn for ten months during work. The motions of spine are fairly free, there has been no increase in deformity and he is free from pain at present, twenty-two months after operation.

CASE XXIII.—Patient aged forty-nine; occupation, cement finisher. Complaint, *pain in back and right hip*. One year and nine months ago fell from a scaffolding about fifty feet high, striking on back. Disability was immediate because of pain in low back and right hip. Was in hospital for four weeks; since then has been treated by strapping, plaster jackets, leather jackets, wearing belts; mechanohydrotherapy. The most relief came from back strapping. The pain in low back and right hip is brought on by walking, stooping, or lightest kind of work.

*Physical Examination.*—There is a depression between the third and fourth lumbar vertebræ, with deviation of the spinous process of second lumbar vertebra to the left. All motions of spine limited, lateral motion limited to right less than to left. Muscle spasm in lumbar region is marked. Abduction, adduction, internal rotation, and hyperextension of right hip cause pain referred to low back region. Straight leg raising is limited equally on the two sides by pain referred to the low back.

*X-ray Examination.*—A lateral crushed fracture of the first lumbar vertebra.

*Treatment.*—One year and nine months after injury, bone graft extending from the eleventh dorsal to the third lumbar, followed by recumbency for four months in plaster jacket.

*Result.*—Eight months after operation entirely free from pain. His back allows forty degrees forward bending, and twenty degrees lateral



FIG. 1.—Case II. Shows but small amount of injury by X-ray, but symptoms pronounced, and an increasing deformity, two bodies being involved in an injury of lesser degree.



FIG. 2.—Case III. Compare with Fig. 3. The adjacent vertebra evidently involved. Lateral crush, slight or none, yet disability still exists.



FIG. 3.—Case V. Shows severe crush, but apparently confined to the one body, which gives better opportunity of union. With indifferent treatment, this case made a good recovery.



FIG. 4.—Case XIV. A severe injury of the combined type of anteroposterior and lateral. The latter element endangers the integrity of the laminae.



FIG. 5.—Case XX. Shows the considerable degree of disalignment in an injury in which there was very little anteroposterior crush. Pain particularly referred was very prominent—always a suggestive feature of this kind of injury.



FIG. 6.—Case XXII. Shows only slight disalignment in a severe anteroposterior crush.



FIG. 7.—Case XXII. Shows marked anteroposterior crush, probably involving body above. The injured interposed intervertebral disc undoubtedly prevents the firm union between the two surfaces of injured bone.



FIG. 8.—Case XXIII. Lateral crush. Shows condition at period remote from time of injury. Bone overgrowth more pronounced in region of injury suggests natural attempt for protection.



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bending, and he is able to do light work. This case was complicated by hypertrophic arthritis of the spine.

CASE XXIV.—Patient aged thirty-six; occupation, machine operator. Complaint, *pain in left leg and low back*. One year ago patient was dragged between rollers of mangle which were about ten inches apart. Entire body went through, head first. Disability was not immediate, was able to walk to street car. In bed two weeks; two weeks later (four weeks after injury) returned to work. Worked for three months when pain in back reappeared, it was localized in the low back and constant. Two months later pain became so severe that patient was forced to give up work. He was treated by local physician four months before entrance to the clinic. Walking about seems to relieve patient somewhat, it being described by the patient as endurable only when walking. He is unable to lie on back or left side because of great discomfort.

*Physical Examination*.—There is a marked list to the left. The lumbar lordosis obliterated. Tenderness is extreme over fourth and fifth lumbar spinous processes. Bending forward, backward and toward the left cause severe pain. Straight leg raising is limited on both sides equally.

*X-ray Examination*.—Crushed fracture of the fifth lumbar vertebra with dis-alignment.

*Treatment*.—Recumbent two weeks, at home, medication, etc., strapping and casts for four months without relief. Bone graft extending from the third lumbar to second sacral vertebrae. Spinous processes of the sacral vertebra are so small that graft was split so as to straddle them instead of the usual technic.

*Result*.—Wearing leather jacket at present, thirteen months since operation. No pain; is doing light work.

CASE XXV.—Patient aged twenty-eight; occupation, brakeman. Complaint, *pain in back and leg, disability complete*. January 10, 1916, patient was caught between freight cars; not much discomfort after being extricated until twenty minutes later, when he started to pull a switch, and suddenly fell and became unconscious. Pain is severe in low back, inability to lie on left side.

*Physical Examination*.—Muscle spasm increased by motion. Tenderness extends from the first lumbar to the fifth, is most marked over spine of the fifth. All motions of the back cause severe pain which is referred to the region of the fifth lumbar vertebra. Adduction, abduction, straight leg raising to 40 degrees, hyperextension of the right thigh cause pain referred to the fifth lumbar. All motions of the left hip are painful except rotation.

*X-ray Examination*.—Distinct crack in lamina and dis-alignment; question of crush of body of fifth.

*Treatment*.—Bone graft operation seventeen days following injury.

*Result*.—Support was worn for eight weeks only. Patient felt so well that he removed support at end of ten weeks, and in three months had resumed his regular occupation.

CASE XXVI.—Patient aged thirty-five; occupation, stone mason.

Complaint, *pain and weakness in back*. One month ago fell sixteen feet, striking flat on back on floor; could not walk, but crawled thirty feet to a spot where he spent the night prone. Pain was very severe and constant in low back. Increased by any motion of the back.

*Physical Examination*.—A gap is easily felt between spines of the twelfth dorsal and first lumbar. Hyperextension of spine causes pain and increases the muscle spasm. All motions of upper lumbar and lower dorsal spine are limited. Straight leg raising right or left to ninety degrees does not cause pain.

*X-ray Examination*.—Crushed fracture of body of the first lumbar.

*Treatment*.—Bone graft.

*Result*.—It is now eleven months since operation and patient is very comfortable and is able to work. Has been working for six months; motions of back fairly free and not painful.

CASE XXVII.—Patient aged twenty-six; occupation, baker. Complaint, *pain and weakness in back*. Four and a half months ago fell forty-five feet, injuring back and fracturing right ankle. About two months later patient noticed kyphos which he thinks is increasing.

*Physical Examination*.—Kyphos at tenth or twelfth dorsal vertebra. All motions of back limited by pain.

*X-ray Examination*.—Compression fracture of the first lumbar.

*Treatment*.—Bone graft operation. Great difficulty was found in incorporating spines of the first and second lumbar vertebrae in graft because of their rotation to the left.

*Result*.—Eleven months after operation had no discomfort, and was working. A light back brace was being worn at this time.

## SURGERY OF SPASTIC PARALYSIS

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SPASTIC paralysis of infancy and childhood is a common affection, and its treatment has been more or less unsatisfactory. While the orthopædic treatment of anterior poliomyelitis has become quite definite and well established, and is productive of splendid results; the treatment of spastic paralysis has been comparatively neglected, and it remains more or less obscure and unsettled, and its results are uncertain.

Tubby and Jones collected 837 cases, of which 510 were hemiplegic, 157 diplegic, 140 paraplegic, and 30 monoplegic. The paralysis may be of intra-uterine origin, due to cerebral defects, hemorrhage and softening, syphilis, specific fevers, eclampsia and convulsions, etc.; or it may be due to injuries to the head during birth; or, finally, it may be acquired after birth from hemorrhage, chronic meningitis, hydrocephalus, etc. It is common in children of premature birth. Thus, it is seen there is a wide variety of causes of spastic paralysis, and according to the degree of injury or lack of development of the brain or the spinal cord there is a wide divergence in the extent and degree of the spasticity and weakness. Unfortunately, many children with spastic paralysis are mentally subnormal or even idiotic. This renders the prognosis more unfavorable and the treatment more difficult.

I shall not take the time to consider the various forms and the symptoms of this affection. Suffice it to say that they are dependent upon the distribution and degree of spasticity and weakness and upon the mental characteristics.

Nor shall I here discuss what cases are unsuitable and what ones suitable for treatment, nor the indications for and the methods of conservative treatment; but shall speak briefly of the various operative measures that have been employed to improve the condition of these patients.

Tenotomy of the contracted muscles is the oldest and the most commonly employed surgical procedure for the relief of spastic paralysis. This permits the limb to assume a normal position. It has two values; it relieves the weak opposing muscles from constant overstretching, and it breaks the vicious circle formed by tendon, afferent sensory nerves, spinal centre, efferent motor nerves, and muscle. If the weak muscles, which are the opponents of the strong contracted muscles, are relieved from the strain of overstretching, they will in a measure recover their strength and be better able to resist the pull of their strong opponents which are temporarily disabled by tenotomy and which will for some time be partially handicapped mechanically by the lengthening which they have suffered. In the second con-

sideration, it would appear that the tension of a muscle is somewhat dependent upon the tension of its tendon. If pull is made upon the tendon of a muscle a message is carried by sensory nerves to the spinal centre, whence an efferent impulse is sent out to the muscle which causes it to contract to resist the tension upon its tendon. Normally such impulses are controlled by the cerebral centres, but in spastic paralysis the cerebral centres have been disconnected from the spinal centres, have lost their control, and can no longer inhibit the excitability of the peripheral arc. Therefore the peripheral arc remains in a constant state of over-sensitiveness and over-excitability. This is manifested in the contracted muscles and the exaggerated reflexes. The tenotomy of a tendon cuts this arc, or circle, at one point, and breaks the stream of afferent impulses that were constantly pouring in upon the spinal centres. The centres, therefore, quiet down, and in their part cease to send forth the continuous stream of efferent impulses to the muscles that kept them in a state of constant contraction.

Unfortunately, tenotomy of contracted muscle tendons has not proved uniformly successful in practice. In many cases there has been a recurrence of the original condition. In numerous other cases an opposite deformity has been produced. A talipes equinus has been converted, for example, into a talipes calcaneus, which is a more disabling deformity.

Therefore, Foerster proposed and executed his posterior spinal root resection. This operation cuts the vicious circle by dividing the sensory nerves just before they reach the spinal centres. This surgical procedure is, however, so difficult and severe as to preclude its common use.

Stoeffel then attacked the problem in a different manner. He pointed to the fact that in spastic paralysis all muscles are alike spastic; and that, for example, in talipes equinus the anterior leg muscles are spastic as well as the posterior muscles, but that the latter are so much stronger they overpower the former. The anterior muscles are overstrained and over-stretched and thus become definitely weakened. This weakness is not a real paralysis. In fact, in spastic paralysis there is no absolute paralysis. In the second place, tendons that often appear contractured are not really so. The muscles are shortened only by spastic contraction that disappears under ether. No real muscle shortening is present. Therefore a tenotomy lengthens a muscle which is not shortened and permits the development of an opposite deformity. If contracture persists under a general anæsthetic it is permanent, and the tendon should be lengthened. Stoeffel therefore proposed to weaken the strong muscles by a surgical procedure and to strengthen the weak muscles by freedom from overstrain and by exercise. Thus he would establish an equilibrium of flexors and extensors, for example, that would maintain the limb in normal position and allow more or less normal function. He weakens the strong contractured muscles by resecting a portion of their motor nerve supply.

To correct talipes equinus the internal popliteal nerve is exposed in the popliteal space. It is dissected into numerous bundles which are found

to supply the various muscles of the calf of the leg. A portion of each bundle supplying a spastic contracted muscle is then excised for a length of one to two inches. Approximately one-fourth to two-thirds or three-fourths of the nerve supply to a muscle is thus resected, depending on the amount of spasticity and deformity present in each case. The electrode is used in distinguishing the nerve-bundles which supply the various muscles, except when the surgeon's knowledge of the anatomy of the nerves enables him to dispense with its assistance.

For contracture of the hamstring muscles, operation is performed upon the sciatic nerve in the upper part of the thigh. For adductor spasm one or both branches of the obturator nerve are excised. In the upper extremity the median nerve is exposed in the flexure of the elbow and the branch going to the pronator radii teres and the branches to the various flexor muscles of wrist and fingers are resected as desired.

During the last four years the author has performed thirty-five Stoffel operations on the popliteal, the sciatic, the obturator, and the median nerves. A complete report of these cases will be published later. The results have been so satisfactory that the operations have been done routinely in the author's orthopædic services at the Episcopal and the Presbyterian Hospitals and in Doctor Ashhurst's service at the Orthopædic Hospital.

The following cases illustrate briefly the results that have been obtained:

CASE I.—C. C. *Spastic paraplegia since birth*. September 14, 1914: Is able to walk with the greatest difficulty. September 26, 1914: Operation upon both obturator and both internal popliteal nerves. April 25, 1915: Able to walk fairly well. Heels come to the floor, but toes strike the ground first. October 19, 1915: Second operation upon both popliteal nerves. January 18, 1916: Heels on the floor in walking. Walks much better.

CASE II.—E. M. *Spastic hemiplegia*. July 20, 1915: Marked flexion of right wrist and fingers. Foot in marked equinus, walks on toes. July 21, 1915: Operation on right popliteal nerve. At the same time the tendo Achillis was tenotomized and the extensor proprius hallucis was transplanted to the head of the first metatarsal. All the flexor tendons of the right wrist were lengthened. December 1, 1917: Walks well, with but slight limp. Foot is straight and firm on the floor in walking. Right hand is markedly flexed at the wrist and the fingers partially flexed in the palm. A Stoeffel operation will now be performed on the median nerve as the tendon lengthening has not cured her deformity.

CASE III.—W. G. *Spastic hemiplegia*. November 1, 1914: Left arm—forearm pronated, wrist flexed, fingers and thumb flexed into palm. No active extension of wrist, slight motion of fingers but none of thumb except slight adduction and flexion. Left leg—walks on toes, no active motion in ankle, tendo Achillis contracted, hollow-foot, hammer-toe. November 4, 1914: Operation on median and internal popliteal nerves, tenotomy of tendo Achillis, and transplantation of

extensor proprius hallucis to the first metatarsal. December 7, 1914: Wrist, fingers, and thumb are straight. May 10, 1915: Can actively extend fingers almost to normal limit, can make good fist, can move wrist feebly. No active supination. September 13, 1915: Good grip, slight control of thumb. Can hold objects in his hand.

CASE IV.—R. J. February 26, 1914: Walks on toes with legs crossed, very unstable. October 2, 1914: Operation on both obturators and internal popliteal. January 9, 1915: Much improved, heels on ground when walking, legs straight, does not drag toes. Walks with braces.

CASE V.—C. J. March 20, 1915: *Contracture of tendo Achillis, ankle and patellar clonus*. March 24, 1915: Operation, partial resection of nerve supply to gastrocnemius, soleus, and peronei. May 1, 1915: Foot in good position. Can dorsiflex foot well. Much improved in walking.

These cases, which are but a few of those operated upon, illustrate the improvement which occurs after nerve resection. In several instances a second operation was performed, when it was found that too little of the nerve supply had been resected at the first operation. It is better to resect too little than too much. In operations upon the lower extremity the results have appeared to be almost uniformly successful and satisfactory. In resections of the median nerve of the arm the results are not functionally so good, although the cosmetic results are satisfactory.

Following operation the after-treatment should be thorough and persistent in educating the weakened muscles and in securing coördination. Unfortunately, the mental condition of the patients and the lack of proper facilities for the work interfere greatly with the training. Notwithstanding these difficulties, the Stoeffel operation appears to the writer to afford the best solution yet offered for these cases.

It may be mentioned that tendon transplantations, especially in the arm, may be productive of more or less improvement. Nutt's operation of intraperineural neurotomy with immediate re-suture has also been performed with success.

The writer has considered a modification of the Stoeffel operation—instead of partial nerve resection, he proposes a transplantation of the same nerves into the weak opposing muscles. Anatomical difficulties would not permit of the universal application of this procedure.

It would be interesting to know what occurs in the muscles following the Stoeffel operation. Part of the nerve supply of the muscle has been removed and a portion of the muscle paralyzed. It seems probable that in time the remaining nerves will neurotize the entire muscle. Only time will tell whether the good results of the operation will be permanent.

Sharpe's cerebral decompression for spastic paralysis is on trial, but it would appear to be of value only in recent cases, and particularly in the new-born.

## CONTRACTURE OF THE BLADDER (HYPERTONIA VESICÆ) DUE TO SPINAL INJURY

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THIS report of an isolated case of a spinal fracture cured by laminectomy is not submitted under cover of a plea for operative interference, but rather to direct attention to the unusual and somewhat exceptional features that characterize it; to emphasize the value of X-rays in localization, and, finally, by the corroboration of findings at operation, to add to our understanding of spinal cord localization. The history follows:

On January 5, 1917, I was requested by Dr. P. L. to see a man, aged forty-five years, who was suffering pain—a severe hemorrhagic cystitis, great frequency and tenesmus with marked pain in the left lumbar region; temperature  $102^{\circ}$ , sweat and much loss of weight.

*Past History.*—On November 9, 1916, he fell from a ladder at a height of 30 feet, sustaining a fracture of both ankles, for which he was removed to a city hospital six hours later. Not having voided the following morning, he was catheterized. Thereafter catheterized *t.i.d.* for six weeks (retention).

No paralysis of the limbs developed; X-ray failed to show injury of the spine. In the meantime, the fractures of both ankles healed kindly in the plaster case. Retention of the urine gave way to repeated frequent urination approaching almost constant dribbling. (True incontinence, no ardor urinæ. Automatic emptying of the bladder.)

*Examination.*—Patient found greatly emaciated; temperature  $102^{\circ}$ ; pulse, 102, chill having preceded. The glans penis was eroded and all the skin about much macerated from the escaping foul-smelling urine. The urine painfully voided was mixed with pus and blood; finger in the rectum caused a gush of urine (automatic). The bladder was found very tender by rectum as well as over the suprapubic region. Tenderness extended along the course of the left ureter to the left kidney (ascending infection?). All the muscles of the left half of the abdomen and lumbar region likewise were spastic. No anæsthesia nor paralysis of the limbs nor loss of any of the reflexes was to be made out at this examination. The possibility of a spinal fracture was entertained none the less to account for the *assumed isolated disturbance of the bladder mechanism*, but the septic condition of the patient demanded treatment of the urinary tract first.

On January 6, 1917, the patient entered the hospital. Permanent catheter was attempted but not tolerated. For a few days, bladder irrigation. As this also taxed the patient and all the symptoms persisted with the addition of calcareous particles, and the patient was losing rapidly in weight, a refinement of diagnosis (pyelitis?) with the cystoscope was attempted. This proved a failure, for the bladder capacity was barely 30 c.c. (contracture). The day following suprapubic cystotomy under general anæsthesia was performed. It was a difficult operation; the peritoneal fold having been drawn far beneath the pubic arch, the abdominal cavity was accidentally entered. This rent

was sutured, at the same time the peritoneum was secured at a higher level of the bladder. The bladder when entered was found to admit the index finger and permitted scantiest excursion of it (contracture). No projection of prostate nor calculus nor ulcer, but the bladder wall was fully  $\frac{1}{2}$  inch thick (hypertonic). Rubber drain into the bladder. Immediately following the operation, improvement of the general condition set in. At the end of two weeks, urine cleared and the drain was removed. After an interval of another week, the wound having contracted, an indwelling catheter was tried to bring about complete closure. This was effected in another week. Now, however, the patient could not retain even the smallest quantity of urine for any length of time (hypertonic) and during this period, in sleep, was incontinent. At times voluntary urination of small quantities was possible. Following such, catheter found the bladder empty. Urine continued clear and urination was no longer a painful act. Bladder could be distended to 60 c.c.

Now four weeks after operation, the patient was out of bed, able to walk and gained considerable in weight. Attention was again directed to the possibility of spinal injury. A marked tenderness over the dorsolumbar region of the left side, also a slight kyphosis taking in the last dorsal and upper lumbar vertebræ was made out. A very small butterfly-shaped area of anæsthesia in the anal fold extending forward to the scrotum was mapped out. No dissociation of heat and pain sensation. Dr. George Jacoby corroborated these findings and added the absence of the cremaster reflex and slightly increased left patellar and left abdominal reflexes. Doctor Jacoby concurred in the diagnosis of spinal pressure from bone injury dating back to the accident. The X-rays, particularly the lateral view, taking in the lower dorsal lumbar region, showed a compression fracture of the body of the twelfth dorsal and first lumbar vertebræ.<sup>1</sup> Doctor Jacoby like myself advised operation for the possible relief of pressure, *i.e.*, decompression to offset and minimize later secondary degenerative changes of the cord. As yet no evidence of the latter had shown themselves, such as spastic contractures or increased reflexes.

*Operation* (February 3, 1917).—Under general anæsthesia. Laminectomy. The spinous processes and the laminæ of the twelfth dorsal and first, second, and third lumbar were removed down to the articular processes. Pulsation of the cord perceptible through the dura. Upon palpation a tense band was felt over the lower part of the exposed dura. Dura incised between two guide sutures. No undue amount of fluid escaped nor evidence of any blood discoloring the same. The opening of the dura was enlarged up and down bluntly. The cord was now seen to be "angulated," corresponding to the altered position of the fractured vertebræ. The height of the angle was at the level of the first and second lumbar vertebræ, corresponding in the cord to the location of the conus. No hemorrhages in the cord. The vessels of the pia, normal. At the location of the band referred to above a

<sup>1</sup> Doctor Caldwell reports: The X-ray plates show a pathological condition in the dorsolumbar region. Apparently the body of the first lumbar vertebra has been crushed into a wedge-shaped mass, the apex forward making a kyphosis at this point.



## CONTRACTURE OF THE BLADDER

number of fine adhesions passed between the dura and the cord. These were separated by a probe which could be passed freely upward and downward along the cauda. The anterior surface of the cord explored with the probe. No injury to the nerve roots encountered. No loose fragments of bone found; only the displaced bodies of the vertebrae above referred to.

It was now evident that resuturing of the dura would subject the cauda to pressure again, since the latter protruded beyond the slit in the dura. Therefore a fascial graft from the fascia of the dorsal muscles  $1\frac{1}{2} \times \frac{1}{2}$  inches was interposed, sutured in place with fine silk, smooth side of the graft facing the cauda. Fluid from the cord no longer escaped. Slight troublesome hemorrhage from the bone was controlled with bonewax. Muscles sutured in layers, then the fascia and finally the skin. Operation lasted forty-five minutes.

*Postoperative Course.*—No more dribbling or incontinence for retention now set in, therefore catheter, *b.i.d.* On the third day suprapubic wound opened, because of retention. From now on, daily bladder irrigations till the urine began to clear. At times the patient manages to void one or two ounces per urethram. At the end of four weeks after the operation, patient discharged, able to walk freely and to void small quantities of urine—three ounces. At no time after operation was there any paralysis of the limbs or the rectum, nor any undue abdominal distention. Improvement of the bladder function progressed steadily. One year later, complete return of urinary function has set in. At no time was sexual function in abeyance, and it is normal now.

*Summary.*—Dysuria was in the foreground, but it was only an incident of the actual condition, and its underlying cause—the spinal fracture—escaped early detection because the early radiograms did not take in the level at which the fracture was located, as did the later radiograms by Doctor Caldwell. All of the phases of dysuria were exhibited in a most exemplary manner, characteristic of spinal cord injury, and their sequence for that reason is bracketed in the history. First there was (atony) attended with “retention” incontinence of overflow. This gave way to “true incontinence” (without ardor urinæ), the so-called “automatic emptying of the bladder,” and finally there was the hypertonic bladder. It was in the latter stage, I first saw the patient.

Characteristics of hypertonia were: intolerance of all instruments and their repulsion when introduced, and the gush of the small quantity of urine when the finger was inserted in the rectum. At operation, the bladder wall was found in contracture, its walls  $\frac{1}{2}$  inch thick and its capacity barely 30 c.c., admitted merely the index finger. Operation relieved all urinary disturbances. The exquisite localization of the lesion in the conus and the isolated and exclusive vesical disturbance establish beyond any doubt that bladder innervation centres in the conus.

The use of fascial grafts to bridge over the gap in the dura, preventing escape of cerebro-spinal fluid and obviating further adhesions or compression of the spinal cord, was most successful.

# LOOSE CARTILAGE IN THE TEMPOROMAXILLARY JOINT

SUBLUXATION OF THE INFERIOR MAXILLA

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IN May, 1916, a patient, M. F., was referred to me by Doctor S. Her chief complaint was inability to close her mouth so that the teeth would come together. It seemed that the entire inferior maxilla was swung toward the right side so that the line of the teeth of the lower jaw was at least one-half inch from the line of the teeth of the upper jaw.

The inability to approximate the teeth reacted disastrously to the patient, for she was unable to chew and masticate ordinary food, and, as a consequence, she lost her appetite and was growing very thin. The present lesion has been present for the past eight months, when it resulted from a difficult effort at mastication. At first the jaw locked, but by persistent effort she was able to release it. This happened several times until the locking in the position above described became permanent and could not be released.

A study of the joint convinced me that the locking was due to a separation of the left interarticular cartilage with a forcing back of the cartilage into the temporomaxillary articulating cavity.

A search of the literature did not disclose any description of an operation for the correction of such a deformity. Accordingly, I devised the following operation:

1. An incision along the auricle and down to the pinna is made. If possible it is made in a skin crease.

2. The skin and immediate subjacent tissue are dissected back towards the face (Fig. 1). Care must be observed not to injure the superficial branches of the temporal—*i.e.*, the posterior and anterior branches. These in many cases are given off immediately above the zygomatic process.

3. If the branches of the temporal artery are given off at a higher level than the malar, a transverse incision is made along the zygomatic process, beginning about 1 cm. anterior to the auricle. Before making this transverse incision the temporal artery should be definitely located by palpation. If the anterior branches of the temporal come off before the malar, an incision parallel to and posterior to them as shown in the cut (Fig. 2) may be made.

4. If the transverse incision has been made the next step is to define the anterior margin of the parotid. Along its anterior edge a perpendicular incision is carried down for a little over 1 cm. If the incision is carried farther the duct of Stenson may be injured, as it crosses the face at this point. The parotid is now dissected downward. The posterior margin of the masseter is now exposed. It is drawn forward. Hæmostasis is now made perfect. If the second incision has been a perpendicular one the third incision (Fig. 3) is transverse slightly above the line of articulation. The



FIG. 1.—Indicates the approximate length and location of the incision.



FIG. 1a.—Shows the normal anatomical relationships (from the Edinburgh Stereoscopic Anatomy). 1, zygoma; 2, condyle of mandible; 3, deep head of the masseter; 4, superficial head of the masseter; 5, sternomastoid muscle; 6, digastric muscle; 7, common facial vein; 8, internal jugular vein; 9, spinal accessory nerve and accompanying artery; 10, post-auricular branch of facial nerve; 11, facial nerve; 12, external carotid artery; 13, superficial temporal artery and auriculotemporal nerve; 14, facial vein.

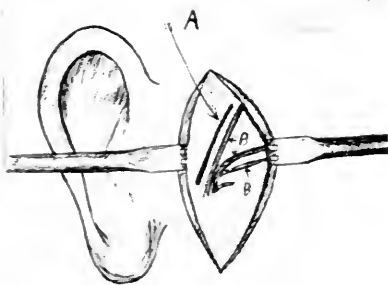


FIG. 2.—Indicates the type of incision through the fascia when the temporal vessels are given off below the zygoma. A, line of incision; B, B, vessels.

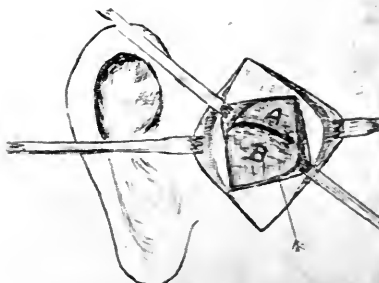


FIG. 3.—The fascial flaps are reflected and the line of incision into the temporocartilage cavity is indicated. A, the fascia over the malar; B, the fascia over the cartilage and joint.

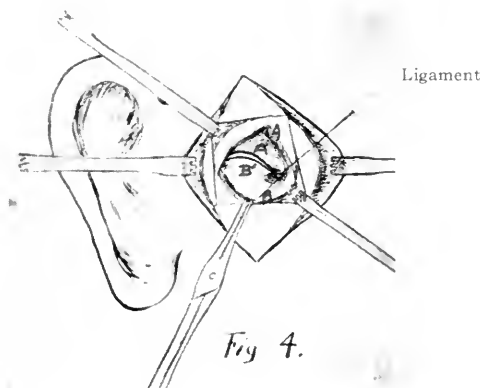


FIG. 4.—The deep fascia is now reflected as shown at *A* and at *B*, where it is grasped by a forceps. *A'* is the periosteum of the temporal bone and *B'* is the fascial covering of the cartilage and the condyle of the inferior maxilla. This seems to act as a separate capsule for the joint between the cartilage and the articulating surface of the inferior maxilla.

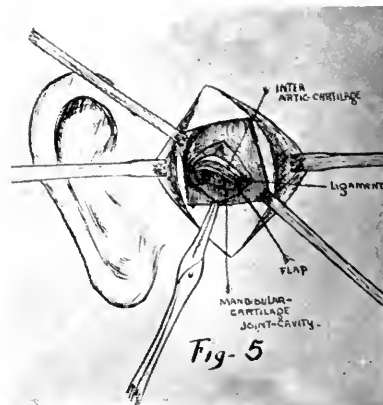


FIG. 5.—The two joint cavities are opened. The cartilage lies between them. The ligament at the anterior extremities of the cartilage where it fuses with the fascial capsule is clearly defined. *A*, the articulating surface of the temporal; *B*, the condyle of the inferior maxilla.

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joint cavity may accidentally be perforated. This is indicated by a discharge of synovial fluid which may be considerable if the joint is in a state of chronic inflammation.

5. The patient's mouth is now opened and the condyloid process is thrown forward, and is felt as a prominence below the zygomatic process and beneath the temporomandibular ligament.

6. The capsular ligament is incised transversely close to the margin of the articular cavity, and the cavity of the joint is opened (Fig. 4). That is the cavity between the cartilage and the articulating surface of the temporomalar bone.

7. The forceps (blunt pointed) are now introduced into the joint cavity to determine if it is entirely free.

8. If the cartilage has been torn free at its anterior end, it is found as in the present instance back in the joint cavity. The anterior edge of the cartilage is now caught and it is drawn forward and is sutured to the periosteal margin of the articular cavity.

9. If the post ligament, *i.e.*, the ligament uniting the posterior end of the interarticular cartilage and the articular cavity, is torn it is sutured to its respective margin by silk sutures, care being taken that the silk does not enter the joint cavity. Normally the cartilage is more closely connected to the condyle of the inferior maxilla than it is to the capsule. It seems to move with the inferior maxilla and to be the buffer between it and the articulating surface of the joint, so that if the cartilage is still attached to the inferior maxilla two cavities are present, the first, which is already entered, as soon as the capsule is incised (Fig. 4), and the second, which is entered by making an incision directly on the surface of the condyle. This opens directly the cavity between the cartilage and the articulating surface of the inferior maxilla. The surface of the condyle may now be examined.

Having the patient open and close his mouth will indicate the different anatomical landmarks. It should be remembered that when the jaw is closed a cavity exists between the head of the inferior maxilla and the articulating surface of the temporal.

10. After the interarticular cartilage has been sutured in place the capsule is closed by a catgut suture, as are also the fascial incisions. The skin is closed either by a catgut suture (subcutaneous) or by horse-hair.

The above operation was performed on our patient and she made an uneventful recovery. She left the hospital in eight days. She was cautioned not to open her mouth to an excessive degree. The teeth were in a perfect alignment and chewing was again normal. The patient rapidly gained in weight and in eighteen months was in perfect health. She now (December, 1917) complains of some cracking in the right joint. The left joint gives her no trouble. The scar is not noticeable.

## THE PREVENTION OF PERMANENT BRONCHIAL FISTULA FOLLOWING LUNG RESECTION \*

A CLINICAL NOTE

By HOWARD LILIENTHAL, M.D.  
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THE possibility of permanent bronchial fistula following lung resection has probably acted as a deterrent to surgeons contemplating this operation. A number of writers have suggested technical points in the treatment of the stump with a view to obviating this condition. It has been advised that after isolation and ligation of the vessels the bronchus be crushed, ligated and turned in by suture, even covering the stump by stitching lung tissue to it and over it with the double purpose of sealing and also of preventing the retraction of the bronchus into the mediastinum. In dealing with normal lung shortly after the infliction of a wound, or in the resection of tumor-bearing lung when there is no inflammatory infiltration of the hilum, these forms of technic are feasible, advisable and perhaps necessary. In resecting a chronically inflamed and densely thickened lobe, however, such niceties of dissection are out of the question. Also, firm adhesions prevent retraction of the bronchus. The danger of immediately fatal hemorrhage from large vessels firmly imbedded in the tough, almost cartilaginous stump is hardly to be avoided unless we revert to the mass ligature principle, in which, after crushing the pedicle, a chain of heavy chromic catgut transfixes every part, bronchus and vascular supply alike. Here, however, temporary leakage of air from the bronchus is almost certain to occur when some days after the operation the stump is cast off.

In the writer's earlier experiences it was feared in each case that the opening might not close. This dread seemed justified because of the bronchial fistulæ which so often followed the drainage of lung abscesses in the bottom of which there was an opening into even a small bronchial branch.

In studying the reasons for the spontaneous closure of the temporary fistula following a lobe resection it was noted that the bronchial opening was far from the thoracic wall and that the cavity which the lobe had occupied became obliterated by the approach of the surrounding soft parts to each other and the further filling in of the hollow by granulation tissue. Gradually less and less air escaped through the long, soft-walled granulating sinus until the fistula closed, then reopened once or twice and finally healed soundly. In later cases the same course was noted in sharp contrast to the permanent fistulæ following the incision of abscesses which were in contact with the chest wall where the open bronchus was close to the surface of the body. It was recognized that the farther from the chest wall the

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\* Read before the New York Surgical Society, January 23, 1918.

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bronchial opening was situated the more likely it was to heal. Then, a few months ago, I resected the left upper lobe in the case of a young woman who had a chronic bronchiectatic multilocular abscess following tonsillectomy. There had been hæmoptysis, fever and profuse fetid expectoration. On July 13, 1917, lobe resection was made through a long sixth interspace incision with section of the seventh, sixth, fifth, and fourth ribs posteriorly after enlarging the wound upward from its posterior extremity. In addition to the drainage in the upper back by resecting part of two ribs a small opening was made in the posterior axillary line between the ninth and tenth ribs and a tube was inserted. The upper wound closed first, but a tube was deliberately kept in the lower opening until the upper wound was soundly healed. The large bronchial fistula was at the bottom, or, geometrically speaking, at the top of a sinus about seven inches long. It finally closed after slow but uninterrupted progress and the patient is well.<sup>1</sup>

During the post-operative period when resection has been done for abscess or chronic bronchiectasis, I am not sure that the temporary fistula is an evil. Indeed, it seems to me that the opening forms a vent for secretions which might otherwise make trouble by forming a pool at the blind end of the ligated bronchus.

Out of six cases, in one—the first—there was no fistula. All the others had fistulæ. All closed excepting one in which the entire right lung is absent. The middle and lower lobes extirpated for progressive suppurative disease fifteen months after tonsillectomy, the upper lobe shrivelling completely, probably because its deformed and adherent pedicle was caught in the ligatures which surrounded the pedicle of the two other lobes. This case is to be recorded later. The patient is working as secretary in a hospital and is in good health, but there is still a large opening in the chest with open bronchus, and another operation may become necessary.

### CONCLUSIONS

1. After lobe resection for chronic inflammation a temporary bronchial fistula may be expected.
2. The fistula will probably close spontaneously.
3. It appears that as a general principle we may assume that other things being equal a bronchial fistula is apt to close in direct proportion to its distance from the body surface.

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<sup>1</sup> Case to be reported in full later.

## THE EFFECT OF SPLENECTOMY ON THE NORMAL INDIVIDUAL AND IN CERTAIN PATHOLOGICAL CONDITIONS\*

BY JAMES MORLEY HITZROT, M.D.  
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IN considering the effect of splenectomy upon the human, three problems present themselves:

First, the effect of splenectomy upon the normal animal. This field has been covered by many observers. The experimental studies of splenectomized dogs, especially by Pearce, of Philadelphia, and his collaborators, are extremely valuable additions to this phase of the question; and the study of the result of splenectomy for traumatism to the normal spleen has given a large amount of material for a study of the splenectomized normal human subject.

Second, the effect of splenectomy in those pathological conditions in which splenomegaly existed, and in which this enlargement of the spleen might be considered as a principal result of the disease in question. Later on, a classification of such pathological conditions will be given.

Here one finds a vast mass of data, pathological and clinical, undigested and little understood. The results of splenectomy from the surgical standpoint have proven the empirical value of this procedure and have shown that splenectomy is neither a difficult nor a dangerous operation in chosen cases.

When cases with splenomegaly and constitutional manifestations well known to the clinician present themselves, it scarcely seems necessary to urge that the surgeon be called in when splenectomy is a relatively easy task. Watchful waiting usually results in perisplenic adhesions and in other visceral changes which thrust upon the surgeon more difficulties than are ordinarily justifiable, and convert a simple surgical procedure into a very complex and dangerous one, and, what is perhaps more serious, lessens the probability of a complete recovery.

The pathological material obtained by operation has, so far, given very little light upon the subject. The lesion, or lesions, in the spleen are identical for given clinical types of the disease, but inasmuch as these lesions are the result of an unknown process, they throw little light upon the causative factors, and there is little except speculative evidence to account for the diseases in question.

Third, the effect of splenectomy in certain pathological blood states in which splenomegaly was not necessarily a factor, but in which the empirical practice of splenectomy has shown by its results that the spleen is, to a certain extent, a factor in the disease.

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\* Read before the New York Surgical Society, November 14, 1917.



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This group of diseases is even more interesting in that it carries one into so many fields for investigation.

There is very little that I can add to this confusing mass of chaotic information. My paper will endeavor to summarize what is known about the anatomy, the physiology, and the clinical features of splenic disease, with special reference to the effect of splenectomy both in the normal and in the pathological animals as gained by observations in seventeen cases of splenectomy (16 personal cases; 1 case reported by Conner and Downes).

Cause for splenectomy	No. of cases	Recoveries	Deaths
Traumatic rupture .....	5	4	1
Cyst (parasitic) .....	1	1	..
Splenic anæmia .....	3	3	..
Hematogenous jaundice .....	2	2	..
Splenomegaly with anæmia .....	1	1	..
Von Jaksch anæmia .....	1	1	..
Pernicious anæmia .....	2	2	..
Spleno-myelogenous leukæmia .....	1	..	1
	—	—	—
	16	14	2

Of all the organs of the body, less is known about the spleen than perhaps any other organ, although the spleen is found practically throughout the animal kingdom. The anatomical relationships and the histology of the normal spleen are sufficiently known to require no mention in this paper.

The weight of the normal spleen is 195 grammes (Sappey).

The blood supply of the spleen is derived from the coeliac axis, as is that of the stomach, pancreas, and liver, showing an association of function, and a correlated vascular development.

The nerve supply of the spleen is derived from the splanchnic sympathetic which would indicate that in its ontogeny the spleen develops before the cerebrospinal system with which it has no connection. The spleen is rich in motor nerve fibres, which when stimulated cause it to contract. According to Schaefer, these fibres are found in the splanchnic nerves which also contain nerve fibres whose stimulation produces a dilation of the spleen. Of the physiological function of the spleen little definite is known (Howell).

Expansion and contraction of the spleen occur during digestion and these movements are synchronous with the digestive periods. The changes in the expansion reach their maximum about the fifth hour of the digestive process, and then gradually subside. In addition, there is a rhythmical contraction and expansion of the spleen in dogs and cats at intervals of one minute which, Roy considers, act to keep up a circulation in the spleen independent of the general arterial blood-pressure.

The remainder of the physiological properties are based upon theories founded upon conditions discoverable at various times in the spleen.

*Theories of the Function of the Spleen.*—1. That it is a blood-forming organ participating in the formation of the red blood-cells.

During the fetal life, and a short time after birth, the spleen produces red blood-

cells, but according to Howell there is no reliable evidence that it does this in adult life. Morris, in estimations of the red blood-cells in the splenic artery and vein, found an increase in the number of red blood-cells in the blood in the vein over that in the artery and in the peripheral circulation. In addition there is also an increased amount of hæmatin and an increased number of leucocytes in the splenic vein (Mayo).

There is evidence (Howell) that the spleen may participate in the preparation of new hæmoglobin, or in the preservation of the iron set free by the destruction of the effete red cells. According to Asher and Grossenbacher, the daily excretion of iron is greater in splenectomized dogs than in the normal dog and occurs during feeding and fasting. It may be found after the tenth week, but is usually compensated for by other organs after the fourth or fifth week.

The iron excretion *per diem* is given by them as 11 mgms. for the normal dog, and 18 to 29 mgms. in the splenectomized animals. Bayer has confirmed these results in splenectomized humans.

2. That the spleen is an organ for the destruction of the red blood-cell which has lost its vitality. This theory is based upon the microscopical evidence of the ingestion and destruction of the red blood-cell by amœboid cells in the spleen. This destruction is especially marked in certain of the acute fevers with splenic enlargement, and the histological picture is quite characteristic (for example, the Rindfleisch cells in typhoid). Pearce and his collaborators have found this destruction in normal animals after the injection of an hæmolytic serum. In the splenectomized animals the red blood-cell destruction took place in the visceral lymph-glands and in the liver, and similar cells of endotheloid shape were present in these organs.

3. That the spleen takes part in the formation of uric acid. Jones and Austrian state that the spleen contains certain enzymes (adenase, guianase, and xanthin oxydase) which convert the split products of the nucleins into uric acid.

4. That the spleen increases the consumption of, and facilitates the utilization of, food.

Richet splenectomized nine dogs, and, by careful comparison to nine control animals, was led to believe that the splenectomized dogs ate more and fattened less than the control animals. He gives tables to prove his conclusions and from them concludes that the spleen plays an important part in the digestion, assimilation, and consumption of food.

Schiff and Herzen (quoted by Howell) believe that the spleen produces an enzyme which is carried by the blood to the pancreas where it converts the trypsinogen into trypsin and hence has an effect upon the protein metabolism. This conversion, according to Howell, takes place in the duodenum, and is due to the enterokinase formed in that part of the intestinal canal.

Mendel and Gibson, from observations on the nitrogenous metabolism in man after the removal of the spleen, state that there are no detectable alterations of metabolism as a result of splenectomy.

My observations confirm those of Mendel and Gibson, and in the human, at least, refute the statement of Richet that the gain in weight and the resumption and maintenance of the weight are slower in the splenectomized than in the normal individual. A growing boy and an adult carefully observed have shown no detectable changes in those functions which deal with the resumption and maintenance of weight, and no observable changes in the normal nitrogenous metabolism, as determined by urine nitrogen estimations.

5. That there is a correlation in function between the liver and the spleen.

Pugliese (Milan) has investigated the correlation said to exist between the liver and the spleen. He investigated the secretion of the bile in the same animal before and after splenectomy and found that the volume of the bile, if anything, was increased, but that the output of the iron in the bile was markedly diminished by splenectomy. This, he considered, may be explained by the diminution of the iron

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content in the liver in individuals losing the increased amount of iron in the faeces described by Asher and his pupils (*loc. cit.*).

Pugliese, furthermore, demonstrated a diminished iron content in the blood, with a decrease in the hæmoglobin and in the number of the red blood-cells.

*The Effect of Splenectomy in the Normal Animal.*—In studying the effects of the removal of an organ concerning whose physiological functions so little is known, many phenomena occur which do not permit of any definite explanation, and which only partly reveal some of the phases of splenic activity due to the compensatory mechanism which brings the splenectomized animal back to a normal state.

The effect of splenectomy upon the normal individual has not only been studied in numerous animal experiments, but has also been carefully observed in an increasing number of splenectomies performed for traumatic injuries, displaced spleens, for cysts of the spleen, in which the individual had a normally functioning spleen before its removal.

It is furthermore necessary, in studying the effects of splenectomy, to eliminate such cases as have coexisting complications which are not referable to the spleen itself, as, for example, coincident injury to other viscera, injury to the pancreas during the removal of the spleen, and the conditions resulting from thrombosis of the various tributaries of the splenic vein, and the extension of the thrombus into other radicles of the portal system or of the portal vein itself.

In addition to the above precautions, in the splenectomized humans, it is also essential to eliminate from the results of splenectomy such cases as show a lesion of the spleen plus some other blood or bone marrow disease, if one is to determine the real effect of splenectomy. This latter group should receive separate consideration, and will be discussed elsewhere.

In general, the results of splenectomy in the normal are:

1. A change in the blood picture which persists for a varying period, but gradually returns to normal.
2. A change in the resistance of the red blood-cells to hæmolysis.
3. An increased output of iron in the faeces which lasts for from four to ten weeks.
4. An increase in the total fat and cholesterin in the blood of splenectomized dogs, which gradually decreased and returned to normal (Eppinger).
5. The blood shows a transient decrease in the antitryptic and bactericidal properties of the serum which rapidly returns to the normal. The agglutinins and opsonins remain unaltered (Bucalossi).

The other mentioned results of splenectomy, such as swelling of the peripheral lymph-glands, hyperplasia of the marrow of the long bones with pain in these bones, and the increase in size of the thyroid, have not received any confirmation in the experience of recent writers on the subject.

The absence of digestion leucocytosis in a case of Moynihan's, recorded by Harrison, was not confirmed in the investigations made by me in four personal cases of splenectomy on normal individuals.

The changes in the blood picture which result from splenectomy have recently been extensively studied by Pearce, of Philadelphia, and his collaborators, and are reported by Musser and Krumbhaar from observations on splenectomized dogs which were under observation from eight to ten months after splenectomy. They state in their summary that there is a gradual progressive anæmia which comes on promptly after the removal of the spleen, and reaches its maximum about the thirtieth to the forty-fifth day, and then gradually begins to return to the normal, which is reached about the third to fourth month, but the hæmoglobin continues to increase in amount as late as the tenth month.

As a rule, they found that the decrease in the hæmoglobin content occurred a little sooner and is more marked than the fall of the red blood-cells; and that the improvement takes place more rapidly in the red cell count than in the blood estimation. The above changes take place gradually.

The white cell count is quite characteristic for all the animals. There is an initial leucocytosis of from 26,000 to 38,000 on the day after the operation, with a rapid fall to 20,000 and then a gradual fall to normal at about the fourth month. The increase in the white blood-cells is chiefly polymorphonuclear in character. There was a transient eosinophilia which in one of the dogs persisted for 113 days and reached as high as from 10 to 32 per cent. in the differential count.

In none of these observations was there any marked increase in the lymphocytes, which averaged from 18 to 26 per cent.

Schultz made daily counts in a man splenectomized for traumatic rupture of the spleen. He found the red cells remained below 4,000,000 for one and a half months, but after the fourth month had risen to 5,200,000. The hæmoglobin remained at 90 per cent. for a few days, and then fell rapidly to 70 per cent. and was 80 per cent. after forty-seven days; but at the end of four months was only 81 per cent.

There was a hyperleucocytosis which at the end of forty-seven days gave 10,000, and at four months 9300. The chief increase lay in the polynuclear cells. An eosinophilia of from 5 to 8 per cent. persisted for seventeen days, and then became normal.

My own observations of the blood pictures following splenectomy in the normal human were made upon six cases, four cases of traumatic rupture, one case of spontaneous rupture of the spleen in typhoid (reported by Conner and Downes, to whom I am indebted for the blood counts up to thirty-four days after splenectomy) and one case of echinococcus disease of the spleen. In all of these the individuals had normally functioning spleens up to the time of the splenectomy.

The six cases are charted graphically to show the blood pictures up to one year after the operation (Charts I-V—Chart of Case III is practically identical to that of Case VI, and the chart of the latter is omitted for that reason).

In the four traumatic ruptures there was a drop in the red cell count

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and in the hæmoglobin which persisted for nearly four months in all except one case in which both became approximately normal at one month.

In the spontaneous rupture, this drop in the red cell count and in the

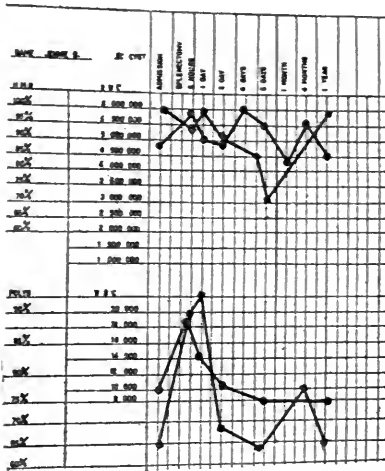


CHART I.—Echinococcus cyst of spleen. New York Hospital. Woman aged twenty-seven; duration unknown; symptoms of pain in left side for nine months. Splenectomy May 21, 1914.

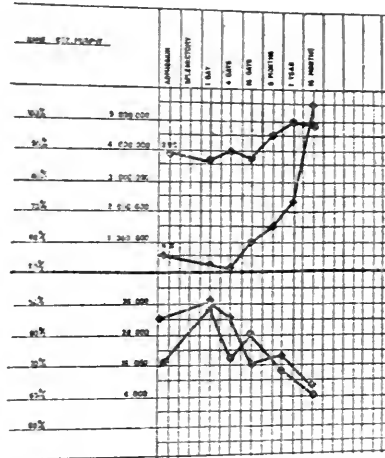


CHART II.—Traumatic rupture of spleen. New York Hospital. Boy aged fourteen. Fall on left side against curb. Splenectomy one hour and fifteen minutes after injury.

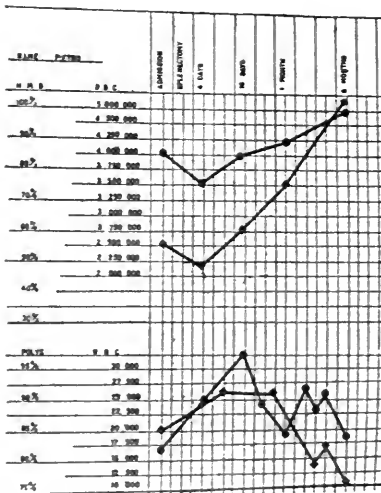


CHART III.—Traumatic rupture of spleen. New York Hospital. Boy aged nine. Struck on left side by auto mudguard. Splenectomy one hour and thirty minutes after injury.

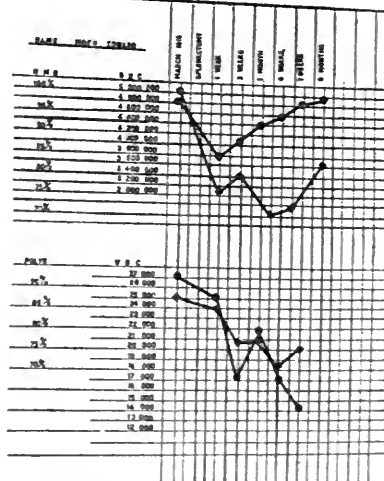


CHART IV.—Traumatic rupture of spleen (injury of spleen due to laceration by fractured rib). New York Hospital. Man aged forty-nine. Fall down elevator shaft. Splenectomy three hours after injury. Sharp edge of broken rib opposite vent in spleen.

hæmoglobin was quite marked and lasted two months for the red cells and four months for the hæmoglobin.

The parasitic cyst showed a curious variation in the red cell count in

that there was a polycythæmia which lasted for the first four days, then dropped below normal but to a very much less noticeable degree than in the other cases. The hæmoglobin fell steadily for one month and gradually rose to normal at one year: That is in the normal human after splenectomy, there is a gradually increasing anæmia which in this series lasted about four months and was most marked in the cases with the greatest loss of blood. The hæmoglobin remained below normal for a longer period than did the red cells and in the majority of the cases it was almost a year before it reached the normal. That is, the findings are quite comparable with those of Pearce and his collaborators for dogs. One case (V. S.) showed a primary transient polycythæmia, and in this case there was no hemorrhage other than that which occurs in any ordinary laparotomy.

The white cell count showed an initial abrupt rise in the white cells which reached 68,000 in the case with the most marked hemorrhage and was lowest in the case without hemorrhage, 19,800. The chief change was in the polynuclear count, and this was most marked in the case with the least hemorrhage. This hyperleucocytosis lasted for from sixteen days to one month, the chief change taking place in the first week and the fall from there on being more gradual.

There was a relative eosinophilia of 4 to 5 per cent. in the traumatic cases and in the echinococcus cyst, which persisted for approximately two months.

That is, in the human there is an initial leucocytosis which is polymorphonuclear in character and which lasts for approximately one month. There was a greater variation here than was observed by Pearce *et al.* in the animals, but in general the conditions were approximately parallel.

It was also noticed, as pointed out by Conner and Downes, that the rapid rise in the leucocyte count became evident before any change in the red cells or the hæmoglobin, as a result of hemorrhage, and this feature should be given more diagnostic emphasis, especially in the traumatic cases, as a sign of hemorrhage.

The two youngest of the traumatic cases showed a few nucleated red cells during the first ten days, as did the spontaneous rupture, but this had disappeared by the sixteenth day. There were also a number of abnormally large cells in these cases during the same period.

A change in the resistance of the red blood-cell occurs after splenectomy.

An increased resistance of the red blood-cell of the splenectomized individual to the action of the hæmolytic agents has been noted by a number of investigators, Bottazzi, Banti, Vast, Pugliese, Luzzatti, Joannovics, Pearce and his collaborators in dogs, Gabbi in the guinea-pig, Domenicci in the rabbit.

The hæmolytic agent usually used was toluylenediamine. Pugliese and Luzzatti used pyrodine; Banti, acetyphenylhydrazine; Joannovics, Pearce and his collaborators, specific hæmolytic serum, and Pearce *et al.*, sodium oleate.

The experimental work done to determine this resistance on the part

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of the red blood-cells has been extensive. In brief, two methods have been used, the injection of a hæmolytic agent and the estimation of the resistance of the red blood-cell to the action of this agent by the comparative production of hæmoglobinuria and jaundice in the splenectomized and in the normal animal. By this method it was found that an increased amount of the hæmolytic agent was necessary to produce hæmoglobinuria and jaundice in the splenectomized animal.

Second, the estimation of the hæmolytic action of hypotonic salt solution on the red blood-cell (fragility test). Charlier and Charlet described an increased resistance to hæmolysis following splenectomy as determined by testing the fragility of the cells of oxalated blood in varying strengths of salt solution.

Pearce and his collaborators in an elaborate number of experiments have shown that in splenectomized dogs after a period of nine days has elapsed, the increase in the resistance of the red blood-cell corresponded to a difference of 0.1 per cent. in the salt solution used, that this resistance did not increase and was present up to seven and a half months after splenectomy.

They furthermore demonstrated by their experiments that the increased resistance of the red blood-cell to hypotonic salt solution and to hæmolytic agents was due, not to an increased hæmolytic power of the animal's serum, or to a diminished complementary value of the serum, but that the power of resistance was inherent in the red cells themselves. Their experiments produce one very interesting paradox, namely:

"In splenectomized dogs anæmia caused by hæmolytic poisons (hæmolytic immune serum and sodium oleate) and by hemorrhage is of a severer grade, runs a longer course, and is accompanied by a less rapid regeneration of blood in the splenectomized than in the normal dog. Also in a splenectomized dog, especially after the use of hæmolytic serum, the leucocytosis is greater than in the normal dog.

"The splenectomized animal almost uniformly exhibits an increased resistance of red blood-corpuscles to hypotonic salt solution, but after the administration of hæmolytic poisons, and especially hæmolytic serum, this increased resistance disappears, and decreased resistance persists for a long period of time. The same change occurs in the normal dog, but in the latter the return to the previous degree of resistance is more rapid than in the splenectomized animal."

In their discussion they state that "this seems, at first glance, to contradict the earlier work in which it is shown that red blood-corpuscles of splenectomized animals were more resistant to hæmolytic agents than in the normal dog, and that in such, hæmolytic jaundice is not so readily produced. On this basis one could hardly expect a hæmolytic poison to cause in splenectomized animals a more severe anæmia than occurs under similar circumstances in the normal animal.

"The present investigation, however, shows this to be the case, and, moreover, that hæmolytic poisons change the more resistant cell of the splenectomized animal to less resistant cells, and this diminished resistance persists longer than in the normal dog. It is evident, therefore, that the immediate destruction of the red blood-corpuscles by hæmolytic agents as shown by hæmoglobinuria and the result of the blood examination, is not the only factor in the production of anæmia, but that in the splenectomized animal some added factor plays an important part. The hæmolytic agent inaugurates an acute anæmia, but the absence of the spleen is an

important secondary factor in increasing the severity of the anæmia, and in either prolonging its course or delaying the process of repair.

"Therefore, the phenomena associated with the absence of the spleen, *i.e.*, the increased resistance of the red blood-cells and the decreased tendency to jaundice after the administration of the hæmolytic poisons, are correlated and intimately associated with the anæmia of splenectomy; but that the anæmia itself is dependent upon some factor as yet unknown which operates in the absence of the spleen. This unknown factor would also operate in the anæmia produced in such animals by hæmolytic serum and, more especially, as the hæmolytic anæmia is characterized by a decreased resistance of the red blood-cells. As the factor dependent upon the absence of the spleen does not operate in the normal animal the latter recovers quickly. It seems possible, therefore, thus to explain the more severe and more prolonged anæmia in such animals even though they may have more resistant corpuscles."

Fragility tests were made upon three of the cases in this series (two traumatic cases, one echinococcus case) in the earlier stages and the red cells found to be more resistant to the action of the hypotonic salt solution than the normal control. This increased resistance began on the eighth, tenth and eleventh days and was present six, seven, and nine months. Two other cases showed an increased resistance on the sixth and eighth months respectively, the only observations made in these cases.

That is, in the human there was a comparable increase in the resistance to hæmolysis of the red cell by hypotonic salt solution similar to that found by Pearce *et al.* in the dog, and that it lasted for approximately the same period.

An increased output of iron in the fæces:

Asher and his pupils have contributed a full literature upon this subject for splenectomized dogs (*v. supra*).

Bayer from Garre's clinic reports the investigation of a case of traumatic rupture of the spleen in which this increase in the output of iron was present as compared to a control patient. He estimated the iron excretion in both patients beginning on the fourteenth day after the splenectomy when they were placed upon a diet rich in iron and one very nearly iron free, and reports the following difference:

Splenectomized	Control
Iron-rich diet, 22 mg. per day.....	16 mg.
Iron-poor diet, 17.8 mg. per day.....	14.7 mg.

Three months after splenectomy he found:

Iron-rich diet, .512 .....	.505
Iron-poor diet, .234 .....	.183

From this investigation up to the third month after splenectomy he concludes that the splenectomized individual excretes a larger quantity of iron than the normal, and especially so during the iron free period.

An attempt was made in one case to estimate this factor, but the great variation in the iron content of the foods tested gave so great a source of



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error that no satisfactory result was obtained. Any method for such estimation would, in view of the very small quantitative differences in the iron excreted, require a synthetic diet in which the ingested iron was absolutely the same in each individual.

A total increase in the fat and cholesterin in the blood:

Eppinger estimated the total fat in 1000 c.c. of blood in dogs which he subsequently splenectomized, and found that there was a definite increase in the amount of fat and cholesterin up to two months after splenectomy, and that it was at the maximum about two weeks after splenectomy.

Bloor, in his recent investigations on the fat content of the blood in normal dogs, found it to be constant both for the individual and for the species. The average variation was 7 per cent., the greatest variation 14 per cent. Bloor believes that there is sufficient reason to expect a similar fat value in humans.

The matter is, as yet, too indefinite to determine its relationship to the splenectomized individual. When splenectomy is contemplated a careful pre-operative estimation of the fat content of the blood followed by a similar investigation under similar dietetic conditions after operation might give some interesting data. No investigations as to this factor were made in this series.

Among the numerous experimental studies upon the function of the spleen and the effect of its removal are the observations by Lewis and Margot that the removal of the spleen from albino mice greatly increased the resistance of the mice towards infection by the bacillus tuberculosis (bovine type). They do not offer any explanation for this resistance to infection.

Blach and Weltmann, in experiments upon the growth of rat sarcomata, state that splenic tissue mixed with the rat sarcoma and injected into an animal, exerted a marked inhibitory influence upon the growth of the tumor tissue. They offer as two explanations of this action (1) that the splenic tissue may increase the natural protective substances of the body, or (2) it may exert a destructive influence upon the tumor cells by reason of some contained ferments.

Vital staining of the red cell by the method of Widal showed an increase in the number of these cells which was greatest in the cases with the most marked hemorrhage and greatest in number in the case with the most nucleated reds. This increase in the vital staining red cells lasted for an average of twelve days, when it began to decrease and regained the normal at an average of the third week.

*The Effect of Splenectomy in Certain Pathological Conditions.*—Splenomegaly occurs under a number of conditions: Some of the types of splenic enlargement such as:

1. Splenomegaly in infectious diseases (typhoid, malaria, ulcerative endocarditis, tuberculosis, etc.).

2. Splenomegaly due to chronic venous congestion as a result of cardiac or pulmonary disease.

3. Splenomegaly in amyloid disease.
4. Splenomegaly in syphilis are rarely surgical spleens, with the exception of the malarial spleen when it becomes chronically enlarged, and the syphilitic splenomegaly in which the lesion seems to be harbored in rare instances (Hartwell).

Splenomegaly in cirrhosis of the liver:

(a) Biliary cirrhosis (Hanot type) including the metasplenomegalic form of the French writers in which the enlargement of the spleen precedes that of the liver and is relatively greater.

(b) Portal cirrhosis—alcoholic and other forms.

(c) The luetic cirrhosis.

(d) The congenital obliteration of the bile-ducts with cirrhosis and splenomegaly.

In all of the above, the coincident disease of the liver renders it unlikely that any operation directed toward the spleen would offer any benefit. (Mayo in a paper before the New York Academy of Medicine stated that the spleen had been removed four times for biliary cirrhosis with benefit. He also considered splenectomy as of value in portal cirrhosis in young individuals without an alcoholic history.)

Splenic anæmia:

(a) Splenic anæmia of childhood (Von Jaksch's anæmia).

(b) Banti's disease (including Egyptian splenomegaly).

Splenectomy is an essential therapeutic measure in all of the above cases, and in cases properly selected the outcome is very gratifying.

In splenomegaly with acholuric jaundice, that is, the so-called hæmatogenous jaundice of the familial type, which begins in childhood, and is stated to run through families, although in the two cases in my experience the women were the only members in the family who were affected, splenectomy is an essential therapeutic measure and a cure usually results.

Pearce and his collaborators offer a very interesting explanation for the production of jaundice in these cases based upon the experimental injection of hæmoglobin into the blood and the production of acholuric jaundice. (See Pearce, Austin, Eisenbry, "The Relation of the Spleen to Blood Destruction and Regeneration and to Hemolytic Jaundice: II. The Relation of Hemoglobinemia to Hemoglobinuria and Jaundice in Normal Animals and Splenectomized Animals." *Journal Experimental Medicine*, 1912, 16, p. 374.)

"Upon these data may be based the following explanation of the mechanism by which free hæmoglobin is removed from the blood serum. Hæmoglobin is not removed by the kidney until its concentration in the blood stream reaches a certain level (0.06 Gm. free hæmoglobin per kilo body weight).

"This constitutes threshold value of the kidneys for hæmoglobin and when it is reached hæmoglobin appears in the urine. When concentration is lower, hæmoglobin ceases; at the same time the liver, and possibly other tissues, take up the hæmoglobin as soon as mere traces are present in the serum, and they continue this removal whether the renal threshold is exceeded or not. The two processes go on simultaneously, the rate of removal when the renal threshold is exceeded being for the kidneys 17 to 36 per cent. and liver and other tissues 64 to 83 per cent. of total amount intro-

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duced. The hæmoglobin removed by the liver is transformed into bile pigment. If the amount reaching the liver is small and is received slowly, the amount of bile formed is not increased above the excretory capacity of the liver, and is removed by the bile-passages without the occurrence of choluria. This is shown in our experiment in which the injections of hæmoglobin were made more slowly than 0.01 Gm. per kilo per minute. On the other hand, if the hæmoglobin is taken up by the liver rapidly and in large amounts, the bile capillaries are overtaxed and the bile cannot be rapidly removed, but is reabsorbed into the blood and choluria develops.

"If this theory is correct we have an explanation of those instances of blood destruction in man characterized by jaundice but not accompanied by hæmoglobinuria. In a slow gradual destruction of the red blood-cells the liver removes the hæmoglobin from the serum so rapidly that the concentration of the hæmoglobin in the serum does not reach the threshold value of the kidneys, and therefore the hæmoglobinuria cannot occur. The constant absorption of large amounts of hæmoglobin by liver and the increase in bile formation which results does, however, overtax the bile-passages, and jaundice occurs.

"In the same way may be explained the continuance of jaundice after the disappearance of transient hæmoglobinuria. A rapid destruction of a large amount of blood raises the concentration of hæmoglobin in the serum so quickly that the threshold value of the kidney is quickly exceeded and hæmoglobin in large amounts appears in the urine. When an amount of hæmoglobin sufficient to reduce the concentration of the serum below the threshold value of the kidney has been removed, a considerable amount of hæmoglobin may still remain in the serum, and it is the slow elimination of this through the liver that causes the choluria to continue.

"The demonstration that the absence of the spleen has no important influence in the elimination of hæmoglobin by the kidney or its transformation into bile-pigments, or on the removal of such pigments is of interest in connection with the observations made in the first paper of the series. That is, the frequent failure of the jaundice to follow the administration of the hæmolytic serum during the early periods following splenectomy. Among the possible explanations was the suggestion that the spleen is in some way concerned in the disintegration of free hæmoglobin, or in the elaboration of its derivatives. The present investigations demonstrate that such an explanation is without experimental basis, though it does not controvert the possibility of the spleen being concerned in liberating the hæmoglobin from the red blood-cells, and suggests that failure of jaundice is due to some other factor or factors. Evidence to indicate that the changes in the blood that follow splenectomy are important factors is offered in the third paper."

### Splenectomy in pernicious anæmia:

Splenectomy, so far, has proven of empirical value in certain types of this form of anæmia, although a much wider knowledge of the types to be submitted to splenectomy must be obtained before it will be possible to determine which group of these cases is essentially the one for such a surgical procedure.

The series here reported contains seven cases of splenomegaly of varying types (splenic anæmia (Banti's), 3; splenomegaly of unknown type with anæmia, 1; hæmatogenous jaundice, 2; Von Jaksch's anæmia, 1), two cases of pernicious anæmia and one case of splenomyelogenous leukæmia.

In these cases the same observations were made upon the blood picture, weight of the individual, the fragility of the red cell and the vital staining with certain exceptions which appear in the text.

Of the three cases of Banti's disease, one case was markedly improved for nine months and then, due to the increasing cirrhosis of the liver, developed ascites, and in the fourteenth month a mesenteric thrombosis from which he died. The case was a late one of its type, and at the time of the operation there was an advanced cirrhosis of the liver with numerous perihepatic adhesions. At the autopsy a well-marked collateral circulation existed between the capsule of the liver and the diaphragm, the parietal peritoneum and the omentum. The mesenteric thrombosis was only a partial one, involving about half of the small intestine, but the patient refused any further operation and died from the results of that thrombosis.

The second splenectomy for Banti's disease is now six months past the operation, and is in splendid health and without symptoms, but it is too early to state anything definite regarding the outcome of the case.

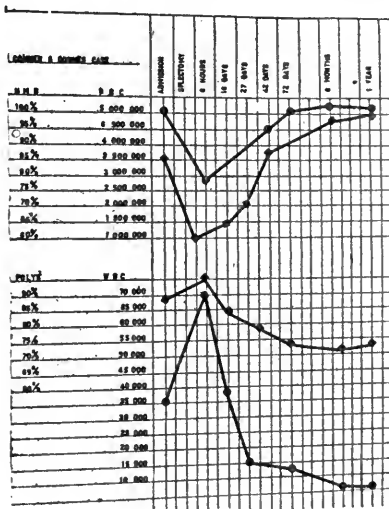


CHART V.—Conner and Downes's case of spontaneous rupture of spleen in typhoid. Splenectomy (Downes) four and one-half hours after rupture.

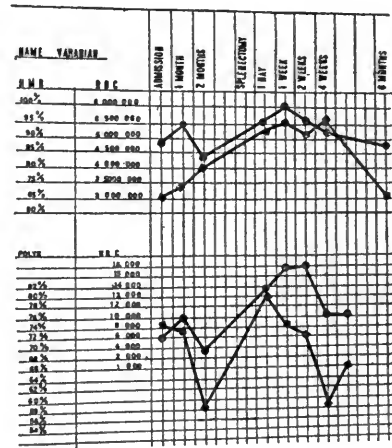


CHART VI.—Splenomegaly, Banti's type. New York Hospital. Man aged thirty; Armenian; duration sixteen years. Splenectomy December 6, 1913. Weight of spleen twenty-seven ounces. Pathological report: Banti's disease (Dr. Elser). Died nine months after operation from mesenteric thrombosis.

The third case has returned to Italy and is serving in the army and the details of this case are too brief to report at length, as the case was followed for only sixteen days.

The two cases followed sufficiently long show a definite drop in the red cell count and in the hæmoglobin beginning at the tenth and the fifth days, respectively, and in both instances this drop was more evident in the hæmoglobin than in the red cell count. The improvement was gradual in both cases and the relative curve is about the same as in the traumatic cases, although the transitions are more gradual (see Charts VI and VII).

The white cells show a definite increase both in the number of the cells and in the polymorphonuclears, although this increase is less marked than in the normal individuals and the resumption of the normal curve occurs earlier, that is, on the tenth and third days, respectively.

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Fragility tests by hypotonic salt solution made before the operation showed a beginning hæmolysis at .48, complete at .36. After the operation (twelve days) this was .46 and .44, with the complete at .28, showing a slight increase in the resistance of the red cells during this stage. Later observations were not made.

Vital staining of the red cell showed two and three cells in 500 red cells counted before operation. Only one observation was made after the operation on the fourth and fifth days, respectively, and this showed 8 and 10 vital staining cells in 500 counted. That is, there is a relatively small increase in the vital staining cells after splenectomy in Banti's disease as represented by the two cases here reported.

Both patients had improved in appearance, felt stronger and both had gained in weight since the operation—one 35 pounds at six months, the other 30 pounds at four months—and both had resumed their occupations. One case showed at nine months the changes mentioned above and the other case is still in good health.

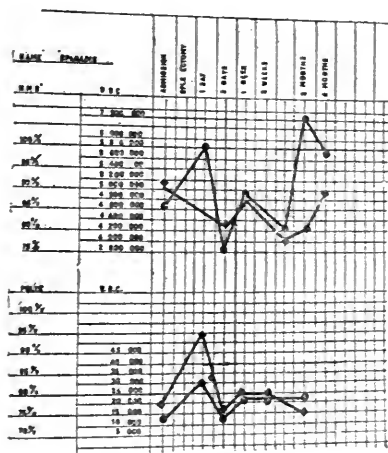


CHART VII.—Splenomegaly, Banti's type. New York Hospital. Man aged thirty; Turkish; duration five years. Splenectomy May 16, 1917. Weight of spleen 1150 grammes.

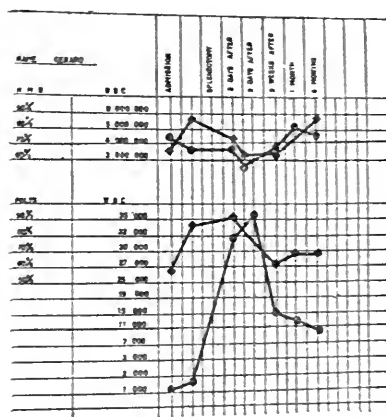


CHART VIII.—Splenomegaly—type not determined. New York Hospital. Woman aged twenty-nine; Italian; abdominal pain and pallor for four years. Splenectomy March 9, 1915. Weight of spleen 870 grammes.

The case of splenomegaly with anæmia classified separately (Case VIII, Chart VIII) was so classified because the pathologist did not consider the case as one of Banti's disease and was unable to give it any definite position among the diseases of the spleen.

There was a slight but perceptible drop in the red cells and the hæmoglobin beginning on the second day after splenectomy with a slow but gradual rise in both up to the third month. The relative decrease was approximately the same for the red cell and the hæmoglobin and the red cell curve was slower but steadier in its rise than the hæmoglobin.

The white cells showed a marked increase in number with a less definite

polymorphonuclear increase, which dropped again to the pre-operative condition on the eleventh day and was apparently normal at the three-month period.

Fragility test: Before operation hæmolysis with hypotonic salt solution began at .44 and was complete at .32. After operation nine days, twelve days and three months, hæmolysis began at .46, .48 and .48 and was not complete, although nearly so, at .26, thus showing very little change in the resistance in the red cell to hæmolysis.

Vital staining is mentioned as normal before the operation. Three days after operation, there were sixteen vital staining cells in 1000 red cells counted, an increase in the vital staining cells.

The patient has shown no change in weight since the operation. Her general health has improved, and three years after operation she reports that she is well but has a small baby and could not appear for examination.

There were two cases of hæmatogenous jaundice in this series, only one of which, the more recent one, was investigated with sufficient detail to make a satisfactory record for this report. Both cases have recovered from the symptoms which existed before the operation performed three and one-half and eight years ago.

The most marked effect shown in the blood pictures in these cases was the rapid rise in both the red blood-cells and in the hæmoglobin which began immediately after the splenectomy, as is especially well shown with Chart IX, Case IX.

In these there was not the temporary anæmia which occurred as the result of the previously analyzed cases, and this fact is worthy of notice as actually differentiating this particular disease from the other types of splenomegaly. In the case of three and one-half years' duration this improvement has been permanent.

The white cell count showed very little change, the increase in the cells being a little less than 10,000 and most marked on the third day after operation, at which time the increase in the polymorphonuclears likewise reached its highest level, 82 per cent.

Fragility tests by hypotonic salt solution before operation showed a beginning hæmolysis at .74 which was complete at .58. This remained constant until the twelfth day, when it began at .62 and was complete at .46. The resistance of the red cell increased constantly until the thirty-fifth day, when hæmolysis began at .48 and was complete at .30. Other observations have occasionally shown an upper level of .46, but the constant level was more frequently .48.

Vital staining showed six to ten cells in five hundred cells counted before operation with a rare nucleated red cell. After operation there was a definite increase in the vital staining cells which was most marked on the eighteenth day, when it was forty-six to sixty in five hundred red cells counted. For the first few days there was a definite increase in the nucleated red cells, about one cell being present to the field. This increase gradually diminished

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and at the sixth month and one year interval was three to five hundred red cells counted.

The patient rapidly improved in weight and strength. The weight before operation was 86 pounds; three months after operation it was 108 pounds.

Splenectomy was done for one case of Von Jaksch's anæmia (this case is reported in full by Stillman, *American Journal Medical Sciences*, February, 1917, vol. cliii, p. 218, Case I).

The child, a girl of nine, showed no improvement under medical treatment and steadily lost ground. Before operation (see Chart X) hæmoglobin was 23, red cells, 2,100,000. No nucleated reds were noticed and the vital cells were 145 in 500 cells counted. Hæmolysis began at .62 and was complete at .44.

Following the splenectomy (see Chart X) there was a rapid rise in the hæmoglobin and in the red cells, which has remained permanent.

The white cells showed no definite change following the splenectomy, and such changes as did occur took place in the polymorphonuclears, which

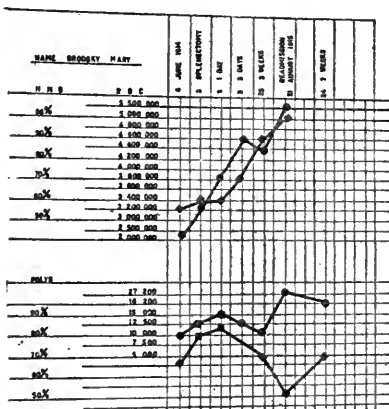


CHART IX.—Acholuric jaundice. New York Hospital. Woman aged twenty-six; recurring attacks of jaundice since childhood; no other members of family affected. Splenectomy June 5, 1915. Weight of spleen 683 grammes.

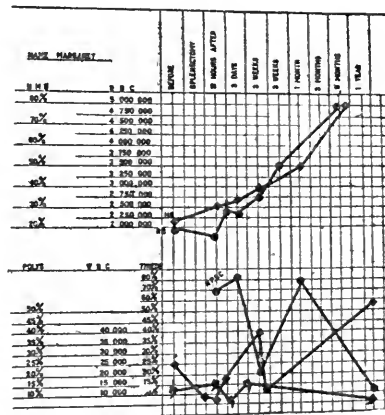


CHART X.—Von Jaksch's anemia. New York Hospital. Girl aged nine; duration seven years; enlargement of spleen and anemia. Splenectomy March 21, 1914. Weight of spleen 1420 grammes.

rose in two weeks to approximately the normal polynuclear percentage (before operation they were only 25 per cent. of the white cells).

One month after operation, hæmolysis began at .50 and was complete at .38. Nine months after operation hæmolysis began at .44 and was complete at .28, showing a marked increase in the resistance of the cell.

The most striking feature of this particular case was the shower of nucleated red cells which was noted twelve hours after the operation. At one time (five days after operation) the nucleated red cells represented 85 per cent. of the nucleated cells in the smear.

The child rapidly improved both in weight and height on exactly the same diet she had had before the operation, and in this case the effect of the

splenectomy was even more striking than that procedure in the acholuric jaundice cases.

The position of splenectomy as a therapeutic measure in pernicious anæmia has not yet been determined, because of the lack of knowledge as to the cause of the anæmias grouped under this common name. So far there have been identified the anæmias due to parasites (*Bothriocephalus latus*); the hæmolytic anæmias due to syphilis, new-growths (carcinoma), and certain intoxications (those of the puerperium for example); the chemical anæmias (potassium chlorate, phenylhydrazine, etc.); and the anæmias due to hæmatogenous jaundice. All the above belong to what may be spoken of as hæmolytic anæmias. Further than that, one may speak of the anæmias classified under the name of pernicious anæmia as (1) due to disturbance of blood formation, *i.e.*, the aplastic anæmias, and (2) the anæmias due to increased blood destruction, or hæmolytic anæmias (Addison-Biermer types).

The anæmias in which there is a disturbance of blood formation, if they can be definitely classified and recognized, cannot be benefited by splenectomy, inasmuch as the trouble does not lie in the spleen, but in the blood-forming organs.

In the other type, *i.e.*, those showing increased blood destruction, many factors as yet undetermined must be solved before the position of splenectomy as a therapeutic measure can be settled. At one end of this group one finds cases in young individuals, all under forty, in which the blood picture is somewhat atypical, in which blood destruction occurs in crises (hæmatogenous crises) with periods of remission, with a definite enlargement of the spleen in which the result of splenectomy brings about a result comparable to that seen in acholuric or hæmatogenous jaundice cases. In these the enlarged spleen seemingly has some increased action in the blood destruction and its removal is followed by definite improvement if not by an actual cure.

Between these two extremes, aplastic anæmia and the type comparable to the hæmatogenous group, is a middle group in which manifestations of inhibition of blood formation or increased blood destruction occur either separately, in conjunction or in sequence. Just when an individual with an increased blood destruction may begin to show aplasia as a result of this constant blood destruction, or whether the factor producing the hæmolysis may likewise produce an inhibition of blood formation coincident with the increased destruction, or whether the inhibition of blood formation may produce an imperfect formation of the red cell which permits of this ready destruction, are problems to be solved.

Splenectomy cannot benefit the cases with signs of marked inhibition of blood formation. In cases with marked blood destruction, in the absence of any other evidence as to the cause of this destruction and when enlargement of the spleen is present, it is a therapeutic measure worthy of further trial. In the intermediate group too many indefinite factors appear to make any general statement, but in the types with evidence of increased blood de-



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struction, if splenectomy is to be used as a therapeutic measure, it should be done before the signs of inhibition of blood formation appear. When these signs of aplasia have appeared it is much less likely that the removal of the spleen can have any effect.

In general, the evidence for splenectomy may be said to be an anæmia of the hæmolytic type with enlargement of the spleen, the occurrence of hæmatogenous crises or evidence of periodic increase in blood destruction and the failure to find any evidence of focal or constitutional disease to explain the cause for the anæmia.

Lukis believes that the presence or absence of the vital staining cell is of prognostic value, *i.e.*, in the cases of anæmia in which vital staining red cells are absent, the prognosis is bad for any therapeutic measure, and conversely when they are present or increased in number the prognosis is better. It would seem wiser from the writer's limited experience to go even further than this, *i.e.*, when the vital staining cells are absent or present only in a

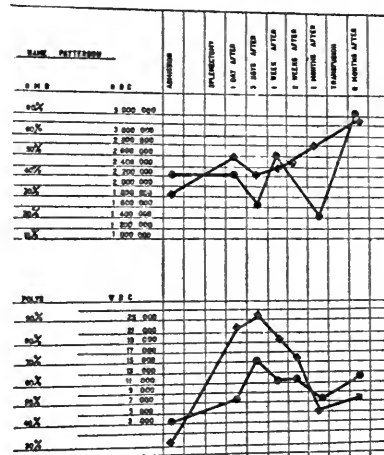


CHART XI.—Pernicious anæmia. New York Hospital. Man aged thirty-seven; duration indefinite two months' history. Splenectomy May 16, 1916.

little less than the normal ratio, splenectomy can be of little or no help. If the vital staining cells are present in an increased ratio above the normal, splenectomy must be considered and the greater this increase the more definitely does the blood present evidence of increased hæmolytic activity as compared to decreased blood formation.

Likewise, those cases with a ratio at or a little above normal which after splenectomy show a marked increase in the vital staining cells are much more likely to be benefited by the operation.

NOTE.—Since this article was written, Minot (*J. A. M. A.*, vol. lxi, No. 23, p. 1926) considers that the blood platelets give the best information as to the activity of the bone marrow. He furthermore states that in the anæmias at the Massachusetts General Hospital studied by Lee and himself there was a greater degree of improvement in the splenectomized and trans-

fused group than in any other group (85 per cent. of splenectomized showed some definite improvement, 45 per cent. showed marked rapid gains). Barker's paper in the same number of this journal is also worthy of perusal.

There were two cases of splenectomy for pernicious anæmia in this analysis:

The first case belongs in what has been spoken of as the intermediate group and belongs to that portion of this group in which the constantly recurring blood destruction was followed by signs of inhibition of blood formation.

Following the removal of the spleen there was little change in the blood picture. Before operation vital staining cells were present two to three in five hundred red cells counted. After operation three to five vital staining cells in five hundred cells counted. The patient was repeatedly transfused with benefit at first but without any benefit in the later stages, and died four months after the operation.

The case was not a suitable one for splenectomy because of the signs of disturbance in blood formation and the absence of any signs of increase in the size of the spleen. She came under observation when these signs were not clearly understood and after long observation outside the hospital. Transfusion and the other methods had failed and splenectomy with transfusion likewise failed. Whether she represents the type of inhibition of blood formation as a result of periodic blood destruction or not is open to question. Study of the case makes that supposition seem likely.

The second case in the series belongs in the group (see page 556) in which the essential factor was that of increased blood destruction. The history of the patient, a man of thirty-seven, was negative except for three or four attacks of jaundice ten years ago. Following this he was perfectly well until April 26, 1917, when he felt weak and dizzy. At this time he noticed that he was pale and he had to discontinue work. He was admitted to the New York Hospital, Doctor Conner's service, where a very thorough examination revealed nothing except a high degree of anæmia of the primary type without evidence of any etiological factor. During his period of investigation on the medical side he steadily grew worse, and his anæmia increased. There was a definite enlargement of the spleen. Urobilin was present in the urine, coincident with the crisis in which the anæmia increased as determined by the blood picture. On May 16, splenectomy was done, and a spleen three times the size of the normal removed.

Before operation his blood picture showed: Hæmoglobin, 32 per cent.; red cells, 1,850,000; color index, 0.89; white cells, 3850; polymorphonuclears, 63 per cent.; transitionals, 2 per cent.; large mononuclears, 5 per cent.; lymphocytes, 28 per cent.; eosinophiles, 1 per cent.; basophiles, 1 per cent.

There were nucleated red cells in small numbers and vital staining cells sixty in five hundred counted. The red cells showed some oligochromæmia, anisocytosis and poikilocytosis. Hæmolysis began at .62 and was complete at .42.

## THE EFFECT OF SPLENECTOMY

Following the operation, there was an immediate improvement in his hæmoglobin and red cell count, a rise in the leucocytes, especially in the polymorphos (see Chart XI). This improvement remained stationary for about three weeks, when he was transfused and 120 c.c. of blood given by the syringe method (Lindaman), following which his improvement was again marked. At the time of this report, six months after splenectomy, he has gained in weight, thirty-seven pounds, he feels perfectly well, and his blood picture is apparently normal.

Twelve days after operation, hæmolysis tests by hypotonic solution showed beginning hæmolysis at .48 and complete at .34. Six months after operation, hæmolysis began at .48 and .46 and was complete at .28.

The case represents the type of increased blood destruction occurring in crises and, while the period is yet too short to state so positively, can, I believe, be represented as a cure. Comparison of the chart of this case with that of Case IX, Chart IX, shows that there is a definite difference in the recuperation of the blood as compared to that in a definite case of acholuric jaundice.

## THE VALUE OF PYLORIC EXCLUSION IN THE TREATMENT OF PYLORIC AND DUODENAL ULCERS

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THE great value of gastro-enterostomy in the treatment of pyloric stenosis is an undisputed fact. If the obstruction is caused by a malignant growth, the operative result will, of course, be of temporary benefit only. If, on the other hand, the obstruction is caused by a benign ulcer of the pylorus or in the duodenum, gastro-enterostomy will effect a permanent cure. In fact, gastro-enterostomy in cases of benign pyloric obstructions gives undoubtedly the best clinical results. The benefit derived from this operation in cases of benign obstruction is much superior to the operative results following simple gastro-enterostomy in cases of non-obstructing ulcers of the pylorus or the duodenum.

The great efficiency of gastro-enterostomy in pyloric obstruction is based upon purely mechanical factors. The pylorus being completely obstructed, no food can pass into the intestines. Simple gastro-enterostomy reestablishes the connection between stomach and intestines and restores an unobstructed way for the passage of food. Gastro-enterostomy thus acts as a simple drainage operation in cases of pyloric stenosis.

It is, however, a well-established fact that the great majority of pyloric and duodenal ulcers do not cause any physical obstruction. The clinical symptoms are not caused by a narrowing of the outlet of the stomach. The food can and does pass freely from the stomach into the small intestines. In fact, a great deal of the distress which the patients complain of is caused by the passage of food over the ulcer-bearing area.

Simple gastro-enterostomy could only be considered as the ideal operation for non-obstructing ulcers of the pylorus or duodenum, if the food could be permanently and absolutely sidetracked. Such result was formerly supposed to be attained. Gastro-enterostomy was first suggested for the treatment of non-obstructing ulcers of the pylorus and duodenum as a purely sidetracking procedure. Extensive experimental work on this question has, however, proved that this hypothesis is erroneous. Yet, even at the present day, many surgeons consider gastro-enterostomy as a safe procedure to keep food material away from the ulcer-bearing area.

As far back as 1900 Kelling made very extensive studies on the passage of the food following a gastro-enterostomy. He established two intestinal fistulæ on gastro-enterostomized dogs, one in the jejunum, distal to the gastro-enterostomy, and one in the duodenum. He then injected 250 c.c. of water, colored with methylene blue, into the stomach and obtained 235 c.c.

## THE VALUE OF PYLORIC EXCLUSION

from the duodenal fistula and not more than 11 c.c. from the jejunal fistula. He concluded that occlusion of the pylorus offers the only guarantee for the patency of the gastro-enterostomy.

Röntgenoscopy and röntgenography offered a very good means for studying this question in animal experiments and on the human being. The literature on this subject has grown so rapidly during the last decade that it would be impossible to give a complete bibliography.

HARTMANN pointed out that the stomach consists of two parts, the cardiac part, which acts as a reservoir, and the pyloric part, which acts as a motor. In other words, the food is mixed thoroughly with the gastric juice in the cardiac part of the stomach before it slides into the pyloric part. After its arrival in the pyloric part, the food is pushed promptly into the duodenum. He concludes from a series of animal experiments that if an anastomosis is made in the pyloric antrum, the evacuation of the food takes place principally through the stoma. If, however, an anastomosis is made in the fundus, the evacuation takes place principally through the pylorus.

GUIBE's viewpoint is even more radical. "All the experiments on animals and observations on men seem to agree sufficiently to prove that as long as the pylorus remains permeable, the stomach has an almost invincible tendency to drive out its contents through this orifice without being inclined to utilize the artificial mouth. Nothing whatever passes through the new opening; on the contrary, everything passes through the pylorus."

CANNON, who studied this subject in a large series of animal experiments, came to the following conclusions: "The idea that gastro-enterostomy represents a drainage operation is wrong. There can be no doubt that in animal experiments the natural exit of the food is through the pylorus and not through the artificial opening, when both ways are offered for the passage of the food."

The same author in a thorough study, published some years previously with Blake, states that in the presence of a patent pylorus the food leaves through the pylorus rather than through the gastro-enterostomy stoma, no matter where the stoma is placed or how large the latter is made. Factors of peristalsis, pressure-relations and difference of food consistency in the cardiac and pyloric portions of the stomach make the pyloric passage a more natural exit than the artificial opening in other parts of the stomach.

HAERTEL observed, in a large series of radiographic observations, that the peristaltic wave of the stomach is unchanged after gastro-enterostomy. It is still directed toward the pylorus. He states that following gastro-enterostomy the food passes in equal parts through the pylorus and the stoma. Schueller's and Petrén's conclusions coincide with Haertel's views.

Outland, Skinner and Clendenning, on the other hand, came to entirely different conclusions. They claim that their röntgenographic experiments prove that gastro-enterostomy is a drainage operation and prevents the passage of food through the pylorus.

Thus, with the exception of Outland, Skinner and Clendenning, all authors above quoted agree that a considerable quantity of food passes through the pylorus, even in the presence of a patent stoma. Such a state of affairs is certainly not desirable. The healing of the ulcer will certainly be hastened considerably if, at least for a certain length of time, the food can be completely and surely sidetracked. Different authors have suggested different forms of pyloric exclusion. In a former paper on this

subject I have described the different methods of exclusion. I shall therefore refrain from discussing the relative value of these methods at length. The unilateral exclusion (Eiselsberg) and a modification of the Biondi method described in my previous paper on this subject are the only methods which guarantee a permanent exclusion. However, a temporary exclusion is sufficient to cure the ulcer. The exclusion stitch, introduced by Berg into clinical surgery, is the simplest and safest method of exclusion.

Berg's method is described by him in the following manner: "A double Pagenstecher linen suture, armed with a needle, is carried around the posterior stomach wall and is held in place by taking several bites in the anterior wall of the stomach. The suture is then tied and the pylorus thus occluded; the knot is buried by a few single stitches."

There is no doubt that röntgenography is a very good method to study the passage of the food following gastro-enterostomy. By this method, however, only short phases of the process are observed, as it is impracticable to watch the whole cycle from the time of intake of the food until complete emptying has occurred. Merely snapshot pictures are obtained, taken at different periods. At some future date this gap may be filled by röntgenographic motion pictures. Furthermore, some of these observations are rather doubtful as to their correct interpretation.

There is, however, a much simpler method which will demonstrate in permanent and preserved form the passage of the food through pylorus and stoma respectively. This method consists in the employment of stained fluids.

The choice of these fluids is a very limited one. In fact, among all the innumerable dyes, thionine blue represents the only one which answers our purpose. The mucosa of the stomach and intestines is covered with a rather thick layer of mucus. For this reason the dye to be employed must have a specific affinity for mucus. Methylene blue, for instance, will pass through the gastro-intestinal tract without coloring the wall, mixing only with the fæces. Another coloring medium which was tried first (*i.e.*, lamp-black) showed the same quality (intense colorization of the fæces without a trace of color on the mucous membranes).

Thionine blue, on the other hand, has a specific affinity for mucus. The first series of experiments was made with the German preparation which gave a dark blue color. The final experiments were made with an American product, as the foreign product was not obtainable on account of the war. This American product, though just as efficient, colored the specimens greenish instead of dark blue.

The experiments were performed in the following manner: Dogs were anæsthetized and a suture gastro-enterostomy or a suture gastro-enterostomy plus pyloric exclusion was performed. Two days after the operation 300 c.c. of a 2 per cent. thionine solution were injected into the stomach through a tube. The dogs were killed under chloroform anæsthesia on the following day.



FIG. 1.—Gastro-enterostomy with pyloric exclusion. (Surg. Path. 4355.)



FIG. 2.—Gastro-enterostomy without pyloric exclusion. (Surg. Path. 4340)





## THE VALUE OF PYLORIC EXCLUSION

The difference in the coloring of the duodenum in the excluded and non-excluded specimens is very obvious (see Figs. 1 and 2). In the first specimen (gastro-enterostomy and pyloric exclusion) the stomach mucosa and the jejunum distal to the stoma show a dark greenish color. The duodenum shows only a slight trace of color. In other words, the exclusion caused practically all of the thionine solution to be driven directly from the stomach into the jejunum without passing the pylorus. The slight trace of thionine solution in the duodenum is explained by the fact that the tobacco-pouch formation of the excluded pylorus allowed a few drops of fluid to pass through into the duodenum. Berg's exclusion is not complete for fluids. However, it prevents solid food absolutely from passing through the pylorus.

In the other specimen (gastro-enterostomy without pyloric exclusion), stomach, duodenum and jejunum show a dark green color of the same intensity. Evidently the solution has passed in about even proportions through the pylorus and the stoma.

This experiment thus demonstrated *ad oculos* the efficient way in which this simple method sidetracks the food.

It must be clearly understood that this series of experiments investigated the mechanical results which follow gastro-enterostomy. The changes produced in the chemistry of the stomach after gastro-enterostomy were not considered in these experiments. It is a well known fact that, following a gastro-enterostomy, bile and pancreatic juice are regurgitated through the stoma into the stomach, thus diminishing the hyperacidity considerably. This change of the chemism of the stomach is of the utmost importance. In fact, we believe that improvements in the clinical condition after gastro-enterostomy without pyloric exclusion are based solely upon the changes of the chemistry of the stomach. Gastro-enterostomy plus pyloric exclusion is however far superior to simple gastro-enterostomy. It gives the patient the benefit of the chemical changes just mentioned and, in addition to that, it safeguards the ulcers against mechanical insults, thus hastening the healing of the ulcer-bearing area.

I have shown in the paper above mentioned that pyloric exclusion does not exclude the pylorus permanently. However, the exclusion persists long enough to effect a rapid cure of the ulcer. It may be very advantageous that pyloric exclusion is of temporary nature only and that after the healing of the ulcer the normal passage of the food through the pylorus is partly restored. For it has been proved that hydrochloric acid will be neutralized much less efficiently if it passes from the stomach directly through the stoma into the intestines than if it takes its route *via* the duodenum. Diarrhœa, frequently encountered after gastro-enterostomy, is probably due to the action of the insufficiently neutralized hydrochloric acid on the intestinal mucosa.

The exclusion stitch does not add in any way to the risks of the operation. No accidents following its use have ever been recorded. Its proper application does not require more than a few seconds. It certainly improves

the chances for a rapid disappearance of the distressing symptoms caused by pyloric and duodenal ulcers.

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## IMMEDIATE JEJUNAL FEEDING AFTER GASTRO-ENTEROSTOMY

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It is generally conceded that the sooner after any operation a patient can be supplied with an adequate amount of fluid and nourishment, and the sooner the normal gastro-intestinal peristalsis can be reëstablished, the better are the chances of the patient for recovery. But this is especially true after gastro-enterostomy for pyloric stenosis, when the patient is usually suffering from starvation which has been allowed to go on for a considerable time, so that not only are the tissues dried out from lack of fluid, but there is also a varying degree of acidosis. These patients, whether suffering from a carcinoma or an indurated ulcer, are usually from thirty to fifty pounds under weight and make exceedingly poor operative risks. When the obstruction is not complete, duodenal, or fractional gastric feeding, by the author's method, together with rectal alimentation and subcutaneous fluid, will often transform an inoperable case into an operable one, but even then the shock of the operation, the exhausting and drying-out effects of the anæsthesia, and the paralyzing effect of handling on the already weakened peristaltic action of the intestine, combine to make the mortality excessively high. The Murphy drip, while of inestimable value in these cases, is not always sufficient to save life, and lavage does not always prevent gastro-intestinal ileus. The usual period of post-operative starvation adds to the complications. The writer has found that it is practicable, at the time of operation, to insert a previously swallowed Rehffuss gastroduodenal tube well into the jejunum and to commence at once, on the operating table, the feeding of peptonized milk, dextrose and alcohol mixtures, thus making sure that the nourishment administered actually is made use of by the body. The method is as follows:

For a day or two, or as long as possible before operation, the Rehffuss tube is left in the stomach day and night, so that the patient may become accustomed to the slight irritation it occasions in the throat, and not pull it out when still under the influence of the anæsthetic. If the stenosis is not complete, or if the operation is being performed for a non-obstructing ulcer, the tube may advantageously be employed for duodenal or gastric feeding, while other preparations are being made for the operation. At the time of operation, which, especially in debilitated patients, should be performed under local anæsthesia, the usual type of gastro-enterostomy is done, but before closing the stomach, the metal tip of the tube is fished out and inserted at least fifteen or twenty centimetres down in the jejunum. The opening is then closed in the usual way. Feeding is commenced at once, on the table, about two hundred or two hundred and fifty mls being given very slowly through a funnel. The fluid should be at a temperature of about 105° F., and may contain whiskey, coffee or other stimulant as required for immediate stimulating effect. Feedings may thereafter be

given by the continuous drip method, but the writer prefers to have the nurse give a definite amount at a definite temperature at regular intervals, thus avoiding any uncertainty such as is occasioned by accidents to the drip apparatus. Two hundred mls of peptonized milk, with fifteen grammes of dextrose and eight mls of whiskey, given at two-hour intervals, will furnish over twenty-five hundred calories in twenty-four hours. The feedings may be given, without awakening the patient, day and night.

So far as the writer knows, this method was first used at the suggestion of the writer, at the Brooklyn Hospital in October, 1917, Dr. Walter A. Sherwood being the surgeon who performed the operation. It was tried twice within a week, the first patient being operated upon for a carcinoma, the second for a large indurated ulcer, a complete pyloric stenosis being present in both cases. The first case was a woman seventy years old; the second, a man of fifty-two, both being in very poor condition, with evidences of myocardial degeneration and marked signs of retention from a chronic nephritis of probably considerable duration. In the first patient the tube was pushed but eight or ten centimetres into the jejunum, with the result that the patient vomited the tip of the tube after about thirty hours, but not until about 3000 calories, in nearly four litres of fluid, had been retained in this way. Feedings by mouth were then immediately begun, and the patient made an uneventful post-operative recovery, without ever having exhibited any symptoms of shock. In the second patient, the tube was inserted twenty centimetres into the jejunum, with the result that it was not vomited. The tube was left in for three days, the patient receiving between 2500 and 3000 calories per day during that period, and making a rapid recovery. In neither case was rectal alimentation considered necessary and no hypodermatic stimulation was required. The first patient had a spontaneous bowel evacuation on the second day after operation. The second patient, who at operation was found to have a dilated, atonic colon, was given powdered aloes through the tube, at once, and pituitary liquid hypodermatically, with excellent result. With the abdomen still open, the effect of injecting the fluid into the traumatized jejunum was observed. The first one hundred mls of fluid distended the jejunum, almost back to the gastrojejunostomy stoma, but then there occurred strong peristaltic contractions, which rapidly pushed the contents downward, so that by the time the full amount had been given the jejunum was empty. This demonstrated that our two-hour intervals are extremely conservative, much more frequent feedings being possible.

The writer considers that he has demonstrated that immediate jejunal feeding after gastro-enterostomy is not only a safe, but an extremely valuable, procedure, and is to be recommended not only in the operations performed for stenosis, but should be tried in all types of cases, as being a more certain, and, in most cases, a less uncomfortable method of post-operative administration of fluid and nourishment than the methods ordinarily employed.

# DEVELOPMENTAL RECONSTRUCTION OF THE COLON\*

ANIMAL RESEARCHES AND CLINICAL REPORT OF TWENTY-NINE HUMAN CASES

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COMPARATIVE anatomy sheds an interesting and instructive light upon the development of the human colon. Huntington,<sup>1</sup> discussing primitive types and in particular the terminal straight segment of the canal which is so much shorter in many vertebrates than in man, says: The primitive condition of the intestinal canal may be observed in some members of man's own class, the mammalia, as in certain edentates. Notable among these is the little ant-eater of Brazil. The termination of the duodenum and the bend in the colon mark the two points at which in the primitive scheme the umbilical loop begins and terminates. These two points we can describe as the duodeno-colic neck or isthmus. In the snapping turtle the same condition prevails, namely the duodenum and the colon approach each other very closely at the isthmus and between these points the convolutions of the intestine extend in a wide circle. "We will find this approximation of duodenum and colon a feature which persists throughout all the later developmental stages of the higher vertebrates and has an important bearing on the final arrangement of the intestinal canal in the human adult."

Thus, not only throughout the fish, the turtles and the frogs, but actually in man's own class, we find types in which the adult corresponds in colonic position and limitation of growth to the primitive form.

Anatomy and embryology are not alone in giving important information as to the relative value to the human organism of the right and left sides of the colon. In a paper read before the section on Pathology and Physiology of the American Medical Association, 1914,<sup>2</sup> I have called attention to the relative inactivity of the right or oral colon in the dog as regards the excretion by it of drugs and toxins compared with the activity of the left or aboral portion of the organ. Briefly, it has been noted by us in company with many others, that even in an animal like the dog, in which there is normally no ascending colon and a rudimentary cæcum, there is a vast difference between the excretory activity of the cæcocolonic region and the caudad portion of the organ. In pilocarpine or diphtheria poisoning, or in the toxæmia of

\* Read before the American Gastro-enterological Association, Atlantic City, May, 1917.

<sup>1</sup> The Anatomy of the Human Peritoneum and Abdominal Cavity, p. 56.

<sup>2</sup> Draper, J. W.: Studies in Intestinal Obstruction. Journal A. M. A., September 26, 1914, p. 1079.

duodenal obstruction, the oral portion of the colonic mucosa remains normal in color while the aboral assumes a brilliant scarlet.

A third avenue for the approach of this interesting problem of colonic variability is found in clinical study at the operation table on adult human beings. It has long been known to biologists that variations in form attest to recency of origin and instability in function. What thoughtful surgeon is there among us who has not been repeatedly struck with the amazing variations in form on the right side of the colon as contrasted with their absence on the left. The occasional exception to this occurs only in the pelvic colon. Moreover, not as a rule having had opportunity for the study either of embryology or of comparative anatomy, he has been at a loss to comprehend or to make any reasonable interpretation of these variations.

It was only after many years' consideration of these abstract phenomena that my colleague, Jerome Lynch, and I became interested in the possible meaning attached thereto and as to whether any utilitarian application thereof could be made in improving the therapeusis of human disease. Especially after reading Madison Grant's notable book,<sup>3</sup> however, we are more than ever convinced that such utilitarianism, be it in pedagogy, in medicine or in other walks of life, is one of the poorest, if not the very worst, characteristic handed down to us from the Nordic race and of very secondary value as compared with search for the abstract truth. We hold with increasing tenacity that no lasting progress can be made in medicine except by approaching its great problems solely from the standpoint of pure science. As Le Père Felix says: "*Nos progrès sont pleins de la sueur des siècles passés.*"<sup>4</sup> It is in every case an idealist, a Pasteur or a Hunter, who has furnished the framework upon which materialism has built.

In a recent unpublished address before the New York Academy of Medicine the English physiologist, Haldane, said that the modern mechanical methods in physiology had about reached the limit of productivity and that a return would shortly be made to some of the methods previously in vogue, and long since discarded by the mechanistic school, notably the theory of vitalism and its allied branches. We are at the parting of the ways.

From our laboratory and clinical studies we are convinced that our provisional hypothesis regarding the cæcocolon, its relative unimportance and frequent danger to the human economy, based as it was upon biologic premises, is correct. Our clinical data and our experimental studies agree with these premises. The two support each other. Bryant's studies,<sup>5</sup> resulting in a classification of human beings and disease into herbivorous, neutral and carnivorous types, as well as the well-known work upon right colonic resection and exclusion of Bloodgood, Mayo, Ochsner, Satterlee and others, compel the general attention of the profession to the cæcocolon. The far-

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<sup>3</sup> The Passing of the Great Race.

<sup>4</sup> Conférences de Notre-Dame de Paris.

<sup>5</sup> Bryant, John: The Carnivorous and Herbivorous Types in Man. Boston Medical and Surgical Journal, September 9, 1915.

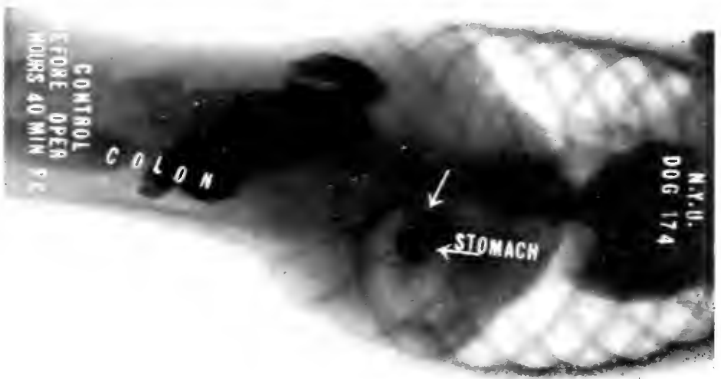


FIG. 1.—Dog 174. Control meal showing residue in stomach.



FIG. 2.—Dog 174. After reconstruction end-to-end anastomosis. No delay, but high mortality.

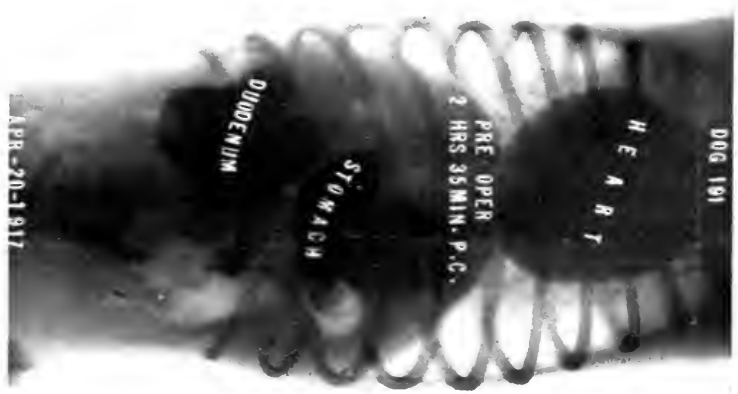


FIG. 3.—Dog 191. Before developmental reconstruction of the colon: end-to-end anastomosis. Note the disproportionate size of the heart shadow in the dog as compared to the human.



FIG. 4.—Dog 191. After developmental reconstruction of the colon: end-to-end anastomosis.



FIG. 5.—Dog 192. Before operation.



FIG. 6.—Dog 192. After operation for developmental reconstruction by lateral anastomosis.



## DEVELOPMENTAL RECONSTRUCTION OF THE COLON

reaching variations in the syndrome of human symptoms, varying in all grades from the neuromental to the arthritic, and which in properly chosen cases are cured or improved by right-sided resection, show the problem to be one of the most fundamental in all medicine. Obviously, it can be solved only by the combined efforts of both clinical and biological workers; the bioclinician having naturally the greatest opportunity for success.

### EXPERIMENTAL STUDIES

These were made on dogs and were, of necessity, limited in scope, owing to the embarrassing fact that the ascending colon is normally lacking in the dog, and that like the ant-eater its duodenum and colonic bend are closely approximated. Thus the colon is exceedingly short and affords but limited chance for operative procedure. We have been, therefore, confined to a technical consideration of the effect of the modified developmental reconstruction which is possible in the dog upon the motility of the stomach as shown by X-ray and upon the relative merits of the lateral, the end-to-side, and end-to-end forms of anastomosis, as observed by the same agent. The accompanying table is self explanatory and supports in general what has been the usual holding in human surgery: that whereas the end-to-end technic gave the most ideal result, its high mortality made necessary a choice of either the lateral or end-to-side implantation.

DEVELOPMENTAL RECONSTRUCTION

Before operation			After operation			
	Elapse of time between meal and X-ray	Remarks—stomach emptying	Elapse of time	Remarks		Number of days post-operative
				Stomach emptying	Anastomosis emptying	
A						
End-to-end anastomosis, 3 cases:						
1. Dog 170....	2 hrs. 50 min.	Slight residue	3 hrs. 20 min.	Normal	No delay	7
2. Dog 174....	3 hrs. 40 min.	Slight residue	3 hrs. 25 min.	Delay	No delay	13
3. Dog 191....	2 hrs. 50 min.	Slight residue	3 hrs. 20 min.	Delay	No delay	14
B						
Side-to-side anastomosis, 3 cases:						
1. Dog 175....	3 hrs. 40 min.	Empty	3 hrs. 20 min.	Marked delay	Slight delay	10
2. Dog 192....	2 hrs. 50 min.	Slight residue	3 hrs. 40 min.	Marked delay	No delay	12
3. Dog 203....	3 hrs. 0 min.	Empty	3 hrs. 0 min.	Marked delay	No delay	12
C						
End-to-side anastomosis, 3 cases:						
1. Dog 186....	3 hrs. 5 min.	Residue	3 hrs. 15 min.	Moderate delay	No delay	13
2. Dog 198....	3 hrs. 10 min.	Residue	3 hrs. 10 min.	Slight delay	Delay	10
3. Dog 206....	3 hrs. 5 min.	Residue	3 hrs. 5 min.	No delay	No delay	6

No surgical research on animals can possibly be made without the conclusion that the persistence in man of the right colonic segment which has come to us apparently through the dominance of its experimental lengthening by the herbivora is ill adapted to our needs. Just what relation the upright position may have to the frequency of localized right-sided constipation, we are not prepared to say, because so little is known of the relations between gravity and intra-abdominal pressure. Constipation unquestionably is merely a part of the protective bodily mechanism. Having learned largely through Barber's researches\* that gravity has little or nothing

\*Barber, W. H.: Segmental Resection for Gastric Ulcer. *ANNALS OF SURGERY*, November, 1916.

to do with the emptying of the stomach after gastro-enterostomy, stoma position and neuromuscular gastric condition being the true determining factors, we are very loath to place much credence in the popular but ill supported theory that the human cæcum often does not empty because of gravity. We are, of course, ready to concede that this factor has its place in the causative syndrome, but realizing the markedly close analogy both as to physiology and as to morphology which exists between the stomach and the cæcum, and to which we have repeatedly referred in previous articles,<sup>7</sup> we feel quite certain that the gravity hypothesis is at best inadequate. Our hesitancy is further increased by the findings of our colleague, McFarland, whose pathological studies<sup>8</sup> of the cæcocolons removed by us show the tissue to present certain atypical characteristics, notable among these being the frequent presence of pigment. This we regard as a highly important contribution. This affords additional basis for the assumption that an inherent biological instability of the cæcocolon as developed in man is more responsible for the symptoms which unquestionably arise from it than the effect upon its emptying by gravity. There is undeniable decadence in function in all organs developing in the higher types in late fetal or early extra-uterine life. We must all remember that colonically speaking we are dogs at birth, the colon reaching only to the liver—thus the left colon, excepting only the pelvic portion, is of extreme age, of constant and important function, of fixed morphology as compared with the right which has not these important attributes. May it not be more logical to consider the relative importance of the right and left sides from the broad standpoint of phylogeny rather than from the narrow viewpoint of descriptive anatomy, and to base our therapeutics upon known biological laws rather than upon unproved and very questionable clinical hypotheses? This must be even more acceptable if the biological laws prove to be supported by our clinical therapeutics in individual human beings. Thus the cæcocolon may be considered the decadent wisdom tooth of the alimentary canal and be treated as such.

#### CLINICAL REPORT

In twenty-nine human cases of developmental reconstruction of the colon five have died, a mortality rate of 17 per cent. An analysis of this mortality is proper at this point because its degree would be deterrent and properly so in the employment by others of this operation. Four deaths occurred in the first eight cases. One death in the last twenty. An analysis shows two important facts. First, that we did not understand how to choose the cases. Second, that our technic has improved. The cause and time of death in the five cases is as follows: In two, both of them epileptic, shock in less than twenty-four hours after operation. In one, hemorrhage six hours after operation. In one, septicæmia, four weeks after operation. Autopsy showed an old perinephritic abscess, unrecognized at time of operation, as probable cause of death. One in a debilitated derelict, five days after operation, peritonitis. We have eliminated much of the post-operative shock by careful avoidance of all traumatism to the nerve centres near the duodenum. The post-operative hemorrhage death was due to the nurse's failure to report patient's condition until too late. The perinephritic abscess case in which death occurred four weeks after operation and in which all bowel functions

<sup>7</sup> Lynch-Draper: The Protective or Esoteric Symptoms of the Alimentary Canal. Virginia Semi-Monthly, March 24, 1916.

<sup>8</sup> McFarland, W. L.: Pigmentation of the Hind Gut. Journal A. M. A., December 8, 1917.

## DEVELOPMENTAL RECONSTRUCTION OF THE COLON

had been completely restored to normal, should not be charged against the series except in an indirect manner. Reclassifying the cause of death, therefore, we find that peritonitis, due directly to leakage from the anastomosis, caused one death, or 3.4 per cent. Shock in two epileptics, or 6.8 per cent.; septicæmia from long standing infection, one death, or 3.4 per cent.; accidental hemorrhage, one death, or 3.4 per cent. This analysis is in no way an attempt to minimize the danger and gravity of this operation, which we feel sure should not be undertaken except after the most exhaustive studies, until competent and long-continued medical care has proved unavailing, and then only by an experienced operator.

Effects of developmental reconstruction upon the patient's symptoms. In order to study these it is necessary to make an attempt at symptom grouping. For our purposes a classification of the patients into two general groups has served the purpose. The first, and by far the larger group, may be termed the "neuromental"; the second, much smaller, the "arthritic." This is an arbitrary setting which perhaps should be discarded and can no doubt be improved upon.

Something should be said regarding the methods employed to group the cases and to reach a decision as to operation. We consider it imperative that each patient should be studied by X-ray, and that the operation is indicated in exceedingly few cases that do not show cæcocolonic delay of 100 hours or more. The symptoms certainly are not due to constipation which we regard definitely as a protective symptom, but rather to the diseased state of the cæcocolon which permits passage of toxins arising either from bacteria or from the gut wall itself. This latter occurs in duodenal obstruction—why not in colonic? Satterlee's studies<sup>9</sup> of the chemical blood picture in colonic toxæmics (human) are of the utmost value and interest, tending, as

### RESULTS OF EXAMINATION OF CASES OF CHRONIC INTESTINAL TOXÆMIA IN WHICH BLOOD WAS EXAMINED CHEMICALLY

Non-protein nitrogen .....	Over normal (45 mg. per 100 c.c.).....	14 cases
	Under normal (30 mg. per 100 c.c.).....	6 cases
Urea nitrogen .....	Over normal (25 mg.).....	4 cases
	Under normal (15 mg.).....	6 cases
	Normal .....	10 cases
Uric acid nitrogen .....	Over normal (3.5 mg.).....	4 cases
	(highest 10.49 mg.)	
	Under normal (1.0 mg.).....	8 cases
	Normal but with subsequent rise.....	1 case
	Under normal with subsequent rise.....	1 case
	(sudden gout)	
Creatinine .....	Over normal (0.5 mg.).....	12 cases
	Under normal (0.1 mg.), sudden rise....	1 case
	Normal (0.1-0.5 mg.) .....	7 cases
Blood sugar .....	Over normal (120 mg.).....	6 cases
	Under normal (50 mg.).....	0 cases
	Normal (50-120 mg.) .....	14 cases

<sup>9</sup> Personal communication.

the accompanying tables show, to indicate that a toxic element arises under conditions of partial or complete obstruction of the terminal gut similar in effect to that of duodenal obstruction, already published by me.

We also regard as imperative not only the removal of all possible areas of infection due to local foci, tonsils, teeth, crevices, etc., but even more particularly the repair of any and all local lesions such as hernia, hemorrhoids and the like, which may have important bearing through reflex inhibition of the right side of the colon. Needless to say, every case should be put through a complete laboratory study, including the Wassermann reaction. In one of our cases this, unfortunately, was not done, dependence being placed upon a 100-hour right-sided X-ray delay. Developmental reconstruction reduced the barium oro-anal time to thirty-six hours, due to the fact that the operation had enabled us to remove an extensive area of partial obstruction at the hepatic flexure—Lynch's "elbow deformity." The patient's symptoms of pain, referred to the rectum, however, persisted until we all, as he said, thought it was "in his head." An "*ex post facto*" Wassermann, however, was three plus.

Our earlier cases now date back nearly three years. The greater number are over one year and a half, the most recent is three months. It is, therefore, probably justifiable to present some utilitarian deductions based upon subjective and objective data. Careful and conservative study of the twenty-four living members of this interesting series shows at the very least a 75 per cent. improvement in efficiency and subjective symptoms. Incidentally, the more we study these cases the greater respect we have for the subjective testimony. The extraordinary accounts by these highly neurotic and often unbalanced patients have in the past been looked upon as worthless, but we have come to regard them with great respect, having often found at operation objective corroboration. Truly, as William Mayo has well said, in rejecting such testimony as a worthless fable, we ourselves are indeed the fool rather than the patient.

*Technic.*—We have resected the terminal 10 cm. of the ileum and the cæcocolon in block to the neighborhood of the right colic artery. This corresponds to a point upon the transverse colon near to the right margin of the omentum. Since in practically all of our cases there has been a common mesentery of the cæcum and ileum so that the entire mass, particularly after careful separation of the mesenteric leaves, could easily be lifted above the belly wall so that both the resection and the anastomosis was done extra-abdominally, we have been able to avoid shock by keeping away from the duodenal centres. Keith's centre at the terminal ileum, while doubtless in close and important neuromuscular relationship with the duodenal centres, as proved by the interesting and conclusive experimental researches of Barber, may apparently be removed without adding surgical shock. This does not mean, however, that we consider ourselves at all informed as to the final post-operative result of its loss to the economy.

## DEVELOPMENTAL RECONSTRUCTION OF THE COLON

### CASE HISTORIES: NEUROMENTAL GROUP

Mrs. R. B. E., aged twenty-eight. This intelligent woman is from the professional ranks and has had the best medical care. She was operated on two and a half years ago. Two healthy children, eight and ten years old. Chief complaint: Chronic constipation associated with extreme mental depression—suicidal; in the State Insane Asylum, Waverly, Mass., six years ago for six months. Husband was told by the alienists that she never could be cured; a hopeless mental case. Now reports herself 80 to 90 per cent. improved and able to care for her household and social duties; bowels regular; no cathartics. When presented recently before the Medical Progress Club of New York she replied to an inquiry as to what her chief trouble had been before the operation, "trying for fifteen years to keep from losing my mind."

Miss A. J. L'E. This woman is a descendant of an old Belgian family and knows her mind. Before operation she had been in the hands of a trained nurse under the most competent medical supervision that money could obtain. She had travelled with the nurse from the Gulf of Mexico to Labrador in the vain search for health. She was regarded by her family and attendants as deranged. Without provocation she flew into the most violent fits of uncontrollable rage. It was impossible for her to associate with anyone. She complained of the most frightful headaches, hemicranial in type. Her bowels were irregular, constipation alternating with diarrhoea. Two years and eight months ago developmental reconstruction was done. Her cæcocolon was grossly and microscopically atypical, being filled with pigment, and the mucosa being nearly destroyed. That this woman's symptoms were directly attributable to the absorption of unknown products from this degenerated and sac-like bowel segment is undeniable, for not only has she returned to her arduous work of teaching, but her headaches are 95 per cent. diminished, her bowels are regular, and she is able to associate with her fellow beings.

Mrs. M. E. R. This woman, forty-four years of age, was for years a chronic sufferer with hemicranial headache; in bed for five days with each attack. In 1909 she had 67 headaches; in 1910, 59; in 1911, 65; in 1912, only 35 (this she attributed to rigid abstinence from meat); in 1913, 49; in 1914, 50; in 1915, 65 (the diet had been rigidly maintained, but the headaches had now reached their former maximum). Developmental reconstruction six months ago. Constipation cured; one headache only, which patient attributed to her over-indulgence socially. Of particular interest from a biochemical standpoint is the fact that she has added both meat and eggs to her diet. For the past six years she had not been able to eat an egg without being certain of having a headache.

### ARTHRITIC GROUP

We have had but one case presenting uncomplicated multiple arthritis. We offer no explanation for this curious evidence of selective action of the toxins. It has happened that this case was evidently well chosen, for she has been rendered 80 per cent. efficient by develop-

mental reconstruction of the colon. While the arthritis was marked in the lower extremities, the patient could still walk by a sort of creeping gait. She had not been able to feed herself except occasionally with a spoon for over two years. She had not been able to turn over in bed for two years; she had not been able to write for three years. After every possible source of infection had been sought for elsewhere, it was decided that the toxins were being distributed from her colon where she presented 100-hour right-sided delay. Seventeen months ago developmental reconstruction was done. In thirty-six hours the patient affirmed that every vestige of pain had left her body and that it was the first time in three years that she had not suffered pain day and night. More remarkable to us was the change about the small joints. How the scarlet color could be blanched as it was in thirty-six hours still remains a mystery. We are aware that Bottomley and others have not had as gratifying results as we are able to report in this case. Whatever the future of this individual may be as to relapse and recurrence, the study of her post-operative condition is of the utmost value in proving that in her case at least the toxins did come from a diseased cæcocolon.

#### INDICATIONS FOR DEVELOPMENTAL RECONSTRUCTION

1. Segmental infection of the cæcocolon. Like any other infected hollow organ it is a constant source of danger.
2. In Lynch's elbow deformity of the mid-ascending colon when the peritoneum cannot be repaired after reduction.
3. In exaggerated non-fusion of mesentery, allowing such freedom of motion as occasionally to result in volvulus. This happened in one of our series.

#### CONCLUSIONS

1. Developmental reconstruction of the colon is an operation which finds justification in heredity, in well-known laws of biology and in clinical study.
2. It is a procedure fraught with danger and one which never should be undertaken until, not alone exhaustive studies have been made, but until modern and well-directed medical therapeutics has failed.
3. Ileosigmoidostomy is unphysiologic and has therefore failed.
4. The subjective symptoms for which the operation is indicated are usually neuromental; the objective symptom is cæcocolonic degeneration. The degree of improvement in our series is amply sufficient to justify the operation in selected cases.
5. Developmental reconstruction has superseded in our clinic all the earlier forms of operative procedure such as ileocolostomy, cæcosigmoidostomy, etc., because we have found it to be no more dangerous operatively and to give better results because it removes the biologically decadent and diseased organ and restores the individual to the carnivorous type of colon undoubtedly best suited to man.

## OMPHALOMESENTERIC DUCT: INTESTINAL OBSTRUCTION

BY MERVIN T. SUDLER, M.D.

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OBSTRUCTION due to Meckel's diverticulum and the various bands and remains of the omphalomesenteric duct is usually of a serious character; because the obstruction is usually of such a type as to involve a loop of the small intestine; and the result becomes serious very rapidly for the patient. A large number of the different varieties of obstruction that can occur have been reported and collected; but the following case seems to be sufficiently unusual to be worthy of report.

January 4, 1917. Case referred by Dr. James D. Lee, Eudora, Kansas.

Patient is a young man, twenty-four years of age. His umbilicus shows as a scar, rather smooth, and not depressed. His father states that he had trouble with it as a child; and that it did not heal until he was four years of age. He has also had attacks of pain on the right side of the abdomen which required a hypodermic injection of morphine for relief. Usually, one injection was sufficient and recovery was prompt. Exercise apparently has something to do with the attacks; and he has been unable to work on account of them. During these attacks he frequently vomited.

Thirty-six hours ago this attack began; and instead of one hypodermic sufficing, several were used; but he grew steadily worse. His bowels moved twenty-four hours before admission to the hospital.

Upon admission to the hospital, his temperature by mouth was normal; by rectum it was 99.8. Before leaving his home, eight miles away, for the hospital, his pulse was about 80 and of good quality. He arrived at the hospital about ten o'clock in a state of collapse, and his pulse could be felt only occasionally and with difficulty. His color, however, remained good.

Under light ether anæsthesia, an appendix incision was made, as his pain had been in this region. When the abdomen was opened a large amount of bloody fluid escaped; and a large part of the ileum, extending from a point about six inches above the ileocaecal valve upwards, was gangrenous. The strangulation was caused by a constricting band about nine centimetres long and about five millimetres in diameter. The smaller end of this was attached to the ileum. The other end (about two centimetres long) was cystic and dilated, was attached just under the umbilicus. This was twisted as shown in the illustration (Fig. 1)—a loop had evidently formed and the intestine had slipped through. The gangrenous intestine was hastily resected, the distal end of the intestine closed, and the proximal end drawn out of the incision

and fastened by a few catgut stitches. While this was being done, the patient's pulse was at times imperceptible; and 700 c.c. of normal salt solution were given subcutaneously. The resected bowel measured 56 inches (140 centimetres) in length. When seen the following morning the patient had taken a glassful of water and was not nauseated; and apparently there was some peristalsis. The dressings were saturated with serum. The pulse was 130, easily counted, and of good quality. The patient's recovery from this operation was rapid and uneventful.

On January 16, twelve days following the previous operation, the patient had no fever, and his pulse was normal. The incision appar-

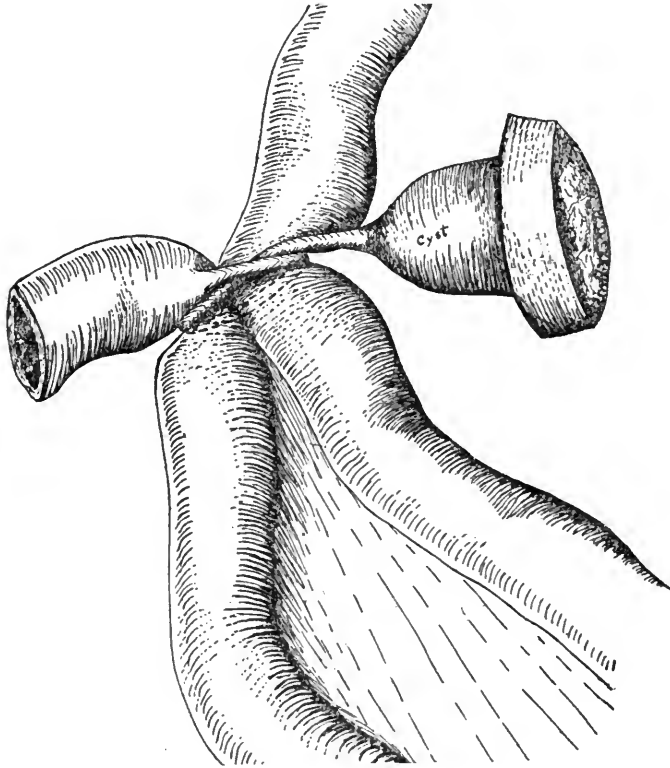


FIG. 1.

ently healed by primary union. An effort was therefore made to anastomose the ileum with the ascending colon and so restore the continuity of the intestinal tract. Under ether anæsthesia, an incision was made through the rectus muscle just internal to the one through which the resection had been done. Immediately upon opening the abdomen about two cubic centimetres of frank pus escaped. There were quite a number of adhesions. The small intestine, which had been brought out of the abdominal incision, was next freed, and the end closed over, first by a continuous stitch and then by a purse-string suture. The intestine in the upper part of the abdomen seemed to be perfectly



free. The ascending colon was freed with some difficulty. A lateral anastomosis was done about two and a half inches above the lower end of the cæcum. The mesentery held the small intestine so that it was not turned; but the resected end pointed downward. The patient left the table in good condition, having a pulse of 110.

Considerable reaction followed this operation, though the patient's condition was never serious. Eleven days following, a small fecal fistula developed. The patient was discharged from the hospital twenty days later, having a granulating area five centimetres square, and a small amount of fecal drainage. The bowels moved naturally, and the pulse and temperature were normal.

On May 16, 1917, as a little fecal drainage still persisted, the sinus was closed under ether anæsthesia.

In February (thirteen and a half months following the operation) he had gained twenty pounds and was feeling well. He had no further digestive disturbance and has been doing farm work without difficulty, and without his old intestinal symptoms appearing.

## CLOSURE OF THE ABDOMINAL INCISION\*

BY CHARLES G. CHILD, JR., M.D.

OF NEW YORK

(From the City Hospital Reports)

IN the closure of every abdominal incision, one immediate and most important indication must be met—the prevention of primary hernia. Does the almost invariable custom of closing the wound with absorbable material meet this indication? To my mind, it does not; and I believe that it leaves much to be desired along other lines as well. In the early days of abdominal surgery, when speed was a factor that had always to be reckoned with, and before the introduction of absorbable suture material, primary hernia was extremely rare. This was because the wounds were closed with heavy silk sutures. While the primary results, so far as hernia was concerned, were good, the late results were poor because of the low percentage of primary union that was obtained in those days. When, later, rapid operating became of less importance, more attention was given to closing the wound. With the introduction of absorbable suture material, closure by approximating layer to layer in proper anatomical relations was adopted. This, probably because of improved asepsis, gave a higher percentage of primary union, with less frequent occurrence of secondary hernia in cases clean at time of operation. In cases septic at time of operation, however, this method yielded a low percentage of primary union, very much lower than in clean cases. With the further improvements in technic of McBurney and Pfannenstiel, post-operative herniæ, both primary and secondary, have been practically abolished, and to-day the primary consideration in closing an abdominal incision made by either of these methods is to secure primary union, and thus avoid the prolonged convalescence that follows in the wake of an infected wound. In the case of the median-line abdominal incision, still so often employed, much greater care has to be used in suturing, both as regards the suture material and the method used, for in such a wound far greater strain is brought to bear upon the sutures uniting it. Just how often a median-line incision in the lower abdomen, closed with absorbable material, breaks open shortly after operation, it is difficult to say. Certainly the accident happens far more frequently than it should.

When an abdominal wound breaks open during a violent fit of post-operative vomiting, it is fair to presume that the sutures used to unite it were not strong enough. Likewise, when a low percentage of primary wound union obtaining with one suture material immediately yields to a high percentage when another material is employed, it is fair to presume that the first was at fault.

What, then, are the requirements we should strive to meet in closing

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\* Read before the Polyclinic Medical Society.

every abdominal incision? It seems to me that two are of paramount importance—prevention of hernia and the securing of primary union.

*Hernia.*—When this occurs shortly after the operation, it is always due to a sudden severe strain. Coughing and vomiting are the most frequent causes of such an accident. Investigation into these cases will usually show that the material employed was of insufficient strength, or had been weakened by premature absorption in the tissues. Catgut has probably been most at fault in this respect.

During the past year I have listened to reports of six cases where this accident occurred. In all, the wound had been closed with catgut, and without exception the secondary suturing was done with silkworm-gut. Secondary post-operative hernia, when not caused by defective technic in closing the wound, is due to infection of the wound. In this respect, it is interesting to hear the opinions of several surgeons of wide experience. Von Rosthorn writes: "During five years I practically saw no ventral hernia in my cases, except when suppuration had taken place." Bier: "I think it depends less upon the suture material used, and the so-called 'method,' than upon a satisfactory healing by first intention. If this does not succeed, then other measures fall short. I hardly ever remember seeing a post-operative hernia when healing by first intention has strictly occurred." Von Eiselsberg: "I have never found a hernia, provided that healing took place by first intention." Duhrssen: "When, however, an abscess occurs in the wound, a hernia follows, no matter how the wound was originally sutured."

It is of the greatest importance in closing abdominal wounds that the tissues should be left in their proper anatomical relations, and so retained, without undue tension or constriction, until permanent union has taken place. When infection occurs in a wound closed with absorbable suture material, these sutures become likewise infected, and slough out, releasing the tissues, so that secondary suturing is necessary if the patient is not to be left with a permanently weakened abdominal wall.

The abdominal incision differs from incisions in all other parts of the body in one very important point—and this is particularly true of the lower abdomen; it is frequently subjected to great increase in tension. This fact should always be taken into consideration when closing the wound, especially in closing one made in the median line, where the strong outward pull of the oblique and transversalis muscles causes an almost constant strain on the sutures. This strain is greatly increased when retching or vomiting occurs; therefore the necessity of suture material of known tensile strength that will not be weakened by premature absorption or infection before the fascia is firmly united.

Separation of the fascial edges, with a high percentage of post-operative hernia, is the rule in wound union by secondary intention. We often hear the remark, "It makes no difference how the wound is closed, provided primary union is obtained"; hence the necessity of a method of closing the incision that will give the highest percentage of primary union.

Of the many features entering into the process of wound infection, two I believe to be of paramount importance; undue traumatism of the tissues at the time of operation, and the use of absorbable suture material in septic cases. Traumatism greatly lessens the vitality of the tissues and their power of resistance, while absorbable suture material introduces what I believe to be an excellent culture medium. Before absorption of the suture material can take place, it must be converted into a soluble gelatin. Gelatin is an excellent culture medium upon which bacteria readily grow. The tissues, when in a normal or approximately normal state, will readily take care of a small amount of infection if the wound has been closed with non-infectable suture material, and is free from areas of necrotic tissue. It is a different story, however, in a wound containing many areas of traumatized tissue, and where numerous foci of pressure necrosis of the tissues have been produced by the tying of strangulating sutures. Such a wound falls an easy prey to subsequent infection, as most anyone's clinical experience will show, and yields a very low percentage of primary union.

Halsted, in an excellent article on ligature and suture material recently published in the *Journal of the American Medical Association*, makes the following pertinent remark: "Catgut, even that which we have no cause to believe is not sterilized, irritates the wound for some reason, perhaps because it serves as culture medium for saprophytic organisms which are carried into it from the top epithelium and follicles of the skin. We have frequently observed this reaction, and have occasionally had an opportunity to compare the reaction caused by catgut with that of fine silk in wounds clinically studied in the same patient at the same time. Let the surgeon interested in making the comparison, when he has occasion to amputate both breasts for malignant disease, take a running subcuticular stitch on one side with catgut and on the other with fine silkworm, and observe the healing wounds from day to day; or when operating on two goitres employ catgut or platysma suture in the one case and very fine silk in the other. There is not only greater local reaction in the cases sewed with catgut, but in them the wounds will occasionally open at one or more points to discharge a few drops of clear or cloudy fluid."

This favorable difference is even more marked with silkworm-gut than with fine silk, and where silver wire is used no evidence of any local inflammatory reaction can be observed. Why, then, continue to produce in the wound conditions so liable to defeat the very object we should strive most to obtain? Prejudice has a great deal to do with this question. As a good illustration of this is an answer I once received from a prominent surgeon, to whom I put the question: "Why do you use absorbable suture material of unreliable strength and uncertain absorbability?" His reply was: "I use suture material that is absorbable because my patients object to the removal of nonabsorbable sutures more than they do to the operation itself." More, I wonder, than they do to the dangers of primary hernia or to a prolonged

## CLOSURE OF THE ABDOMINAL INCISION

convalescence accompanying an infected granulating wound, with a possible secondary operation for hernia.

I do not believe that absorbable suture material should be used in the closure of the abdominal incision, for its unreliability is too great. In cases septic at time of operation, I feel certain it should never be used.

Only a short time ago, in discussing this point with a surgeon who had just finished reading a paper on a new method of wound closure with catgut, I called his attention to the fact that his cases showed only about 67 per cent. primary unions. "Oh," he replied, "but many of the cases in this series were suppurative processes, where it is always difficult to get primary union!" This seems to be a very current surgical belief; that it is a heresy I shall endeavor to show.

Some years ago I published my results with the use of catgut and with silk as a suture material in closing the abdominal incision. The results were as follows:

### CATGUT

Primary union in clean cases.....	70.5 per cent.
Primary union in septic cases.....	50.0 per cent.
Percentage of cases septic at time of operation.....	26.0 per cent.
Average primary union .....	60.2 per cent.

The catgut not only gave a low percentage of primary union in the clean cases, but in the suppurative processes actually yielded one infection for every two cases operated upon. I then abandoned this material and in the next series of cases used buried silk and silkworm-gut in the skin, with the following gratifying results:

Primary union in clean cases.....	91.2 per cent.
Primary union in septic cases.....	95.0 per cent.
Percentages of cases septic at time of operation.....	29.8 per cent.
Average primary union .....	93.1 per cent.

Since that time I have used a method which I described in the *Journal of the American Medical Association* in 1907, and with which the results have been so near perfection that I feel it worthy of a more extended report. The essential feature of this method, closure of the wound with nonabsorbable sutures fastened outside of the skin and subsequently withdrawn, I afterward learned was described by Doctor Haughey, of Battle Creek, some years before my article appeared, and to him I gladly acknowledge priority. We both used silkworm-gut, his being an over-and-over stitch shotted outside the wound, while mine was a continuous mattress stitch, the ends tied over gauze. The mattress stitch I found gave better approximation of the tissues, and could be more easily withdrawn. The long ends permitted a reopening of the wound when necessary without taking out the sutures.

This method will guard absolutely against tearing open of the wound, and will give a high percentage of primary unions. In the hands of a clean operator, it will give primary union just as often in the cases septic at time

of operation as in the clean cases. I now use a No. 23 silver wire introduced on a linen thread carrier in place of silkworm-gut.

*Technic.*—The closure of the wound is effected as follows:

*Peritoneum:* Where the opening is small, it is closed with a purse-string suture of fine silk or linen thread. This introduces a minimum amount of suture material, and turns the raw edges of the peritoneum outside of the abdominal cavity, preventing intestinal or omental adhesions. Longer incisions are closed with a continuous suture of silver wire brought out through the skin or a buried one of fine kangaroo tendon.

*Fascia:* Here a continuous mattress suture is used. The free ends are brought out through the skin, one inch from the angles of the wound, and fastened over a roll of gauze to the free ends of the subcuticular stitch uniting the skin.

*Fat:* When the fat is of extensive thickness, it is likewise brought together with a continuous suture, emerging at the angles of the wound.

*Skin:* A subcuticular suture brings the skin together. The free ends are brought out through the skin one inch from the angles of the incision and on the opposite side from the ends of the fascial stitch. A small roll of gauze is then laid over the wound, the sutures given a final tightening, and fastened, skin ends to fascial ends.

*Subsequent care:* On the second day the dressing is taken down and the roll of gauze cut in two so as to allow proper inspection of the wound. This should be examined every day or so that any effusion of serum or blood clots in the wound may be detected early and liberated before the formation of pus takes place. By this precaution wound infection from the suppuration of an unabsorbed effusion of blood-clot will often be avoided. The more or less common practice of not looking at the wound for nine or ten days, or until an elevation of temperature and pulse develops, is only too often responsible for cases of secondary union. When the elevation of temperature and pulse occurs, pus has formed and secondary union is inevitable.

If infection should occur in a wound closed by the above method, the sutures are unfastened and the skin one withdrawn to allow free drainage. Where the infection extends under the fascia, the fascial suture is not removed, but the edges of the fascia are separated upon it to allow proper cleansing. Later, when the infection has subsided and union begun, traction on the free ends of the suture brings the fascia together. As this suture is not tied in the fascia, it does not slough out, but gives perfect control of the fascial flaps until removed. Thus, firm union of the fascia in infected cases as well as in clean cases becomes possible without resort to secondary suturing. If the case is one of appendicitis, where drainage has been employed, the free ends of the sutures are left loose until the drain is removed, and are then tightened.

By this method many indications are met. Halsted, in the article above referred to, speaking of faulty technic, says, "One should not bring parts together in such degree of tension as to cause necrosis, or interfere greatly

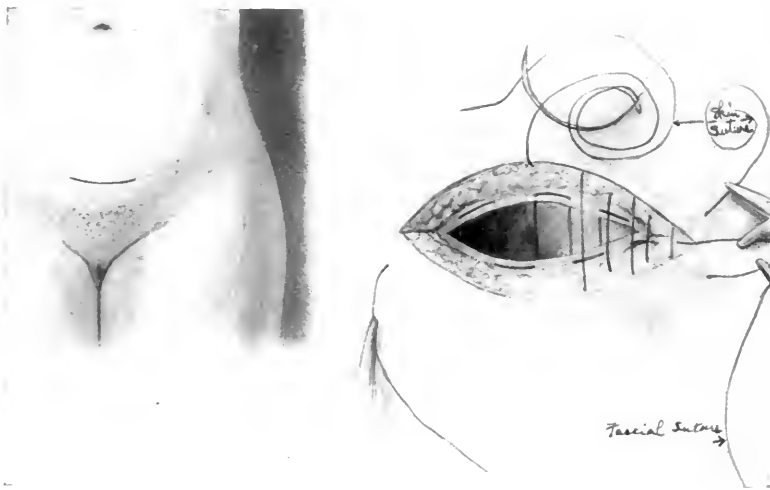


FIG. 1.





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with the blood supply, for nothing is gained by so doing, and decided harm may result." To this I heartily subscribe. Every ligature or suture tied in the wound, if tied tight enough to accomplish its purpose, includes in its bite a portion of devitalized tissue, the centre of an area of pressure necrosis, a foreign body, a menace to wound union; therefore, with the above method, we tie no sutures in the wound. The ends of the sutures are brought out through the skin and fastened over a bolster of gauze outside of the wound. This method snugly approximates the tissues, but does not impair their nutrition or in any way interfere with their circulation. Furthermore, if at any subsequent time we desire to liberate the tissues temporarily it is only necessary to release the outside fastenings.

I have spoken of the advisability of this in infected wounds, and would further call attention to its value in reopening the abdomen where secondary hemorrhage may have occurred.

In one of my cases, where this accident happened, the wound was reopened, the hemorrhage controlled, and the wound reclosed without the removal or re-introduction of a single suture.

Doctor Halsted further says: "For sewing up an abdominal wound, where it is necessary here and there to take heavy top stitches, perforating skin and muscles, silver wire serves admirably; when the section can be approximated without tension, we usually employ unrepeatd perforating stitches of very fine silk. If the skin edges have to be brought together under considerable tension we recommend a subcuticular stitch of silver wire."

Seldom, if ever, in my experience have I found it necessary to take such deep mass sutures, and I notice with many operators a custom of reinforcing their abdominal wounds with such sutures, either of heavy wire or of silk-worm-gut. Some place as many as four or five of these through-and-through sutures in addition to continuous or interrupted sutures of catgut in the muscles, fascia and skin.

This certainly is a complicated and time-consuming procedure. Of the tissues held by the through-and-through nonabsorbable sutures, the fascia is the only one of importance, and this, in the method I have described, is held in closer and better approximation with one suture than is possible with numerous interrupted sutures enclosing the skin and muscles as well.

This "three-suture" method, which is also a "three-layer" method, appeals to me greatly, and the results obtained with it in a large number of cases have been most satisfactory. In the last 100 cases on the Gynecological Division, where it was used, the percentage of primary union was 95 and the percentage of cases septic at time of operation 17. In the five cases that failed to unite by primary union, the colon bacillus was responsible for two, a retained blot-clot for two, and in the other a slight skin infection (the patient removed the dressing on the second day after operation, and tried to take the sutures out).

# A COMPOSITE STUDY OF THE HYPOGASTRIC ARTERY AND ITS BRANCHES

BY BENJAMIN LIPSHUTZ, M.D.  
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(From the Daniel Baugh Institute of Anatomy of the Jefferson Medical College,  
Philadelphia)

THE blood vascular tree has at all times been a particularly interesting phase of anatomical study. Its influence on the development of the individual, its practical importance in medicine, and the necessity for the surgeon to thoroughly orient himself with it give additional stimuli to further our knowledge concerning it.

Bader in 1866, Krause in 1868, and Ruge in 1883 commented upon the regularity and frequency of arterial variations and suggested grouping these variations into anatomic types. This phase of anatomical study, the establishment of anatomic types, aims to generalize the variations of the large arterial trunks of the body, to arrange them into a form more easily comprehended and retained and, if possible, to clear the unbelievable confusion and chaos that exist in the literature on arterial variations.

The observation and classification of the branches of any one of the large arterial trunks, in a sufficiently extensive series of cadavers, disclose the fact that variations of the blood-vascular tree fall naturally into distinct types. This conclusion is supported by the studies of Hitzrot on the axillary, Bean on the subclavian, and those of the writer on the femoral and celiac axis arteries. Mention is made in the studies of the femoral and celiac axis arteries of the occurrence of numerous minor arterial variations not entirely in accord with the described and classified types, yet the arteries observed allow of a distinct grouping into definite and well defined types. Analogous results are found in the present study of the hypogastric (internal iliac) artery.

This paper, the third of the blood-vascular tree studies, presents a composite study of the hypogastric (internal iliac) artery, and is based on records and observations made from student and personal dissections at the Daniel Baugh Institute of Anatomy of the Jefferson Medical College. Dissections of 93 cadavers were recorded: 72 male white, 11 female white, 7 male negro, and 3 female negro. There were 91 dissections of the hypogastric artery on the right side of the body and 90 dissections on the left side, making 181 dissections in all.

Section A of this paper presents observations on the point of bifurcation of the aorta, and the length and point of bifurcation of the common iliac and hypogastric (internal iliac) arteries. Section B contains a description of

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the types of hypogastric artery. Section C embraces a description of the individual branches of the hypogastric artery. Section D summarizes and discusses the results of the present study.

### SECTION A

In the course of the observations on the hypogastric artery, the point of division of the abdominal aorta was found as follows:

	Per cent.
Opposite the	
Third lumbar vertebra.....	4
Intervertebral disc between the third and fourth lumbar vertebræ..	9
Fourth lumbar vertebra.....	59
Intervertebral disc between the fourth and fifth lumbar vertebræ..	20
Fifth lumbar vertebra.....	8

Schwalbe and Pfitzner found the division of the aorta opposite the top of the fifth lumbar vertebra in 20 per cent. of their cases, and opposite some part of the fourth lumbar in 73.3 per cent.

Quain and Dwight report the following observations:

	Quain Per cent.	Dwight Per cent.
Opposite third lumbar .....	3	2.8
Between cartilage of the third and fourth lumbar vertebræ	6	3.5
Opposite fourth lumbar .....	62	76
Between cartilage of the fourth and fifth lumbar vertebræ	14	5
Opposite fifth lumbar vertebra.....	11	11.5

*Arteria Iliac Communis.*—The length of this artery presents considerable variation: Rauber gives its length as 4 to 6 cm.; Henle 2 to 8 cm. Sappey gives its normal length as 6 cm. Quain's observations vary from 2.5 to 10.1 cm.

The author's observations as to the point of division and length of the common iliac artery in 181 dissections are as follows:

	Number of arteries	Per cent.
Opposite fifth lumbar vertebra.....	24	14.5
Between fifth lumbar vertebra and superior margin of sacrum .....	120	85.5
Length of common iliac artery:		
2.5-4 cm. ....	29	15.2
4.0-5 cm. ....	59	36.0
5.0-6 cm. ....	52	27.2
6.0-7 cm. ....	11	5.8
7.0-8 cm. ....	19	10.0
8.0-9 cm. ....	10	5.2

There is a well marked tendency for the left common iliac artery to bifurcate at a lower level than the right. When the common iliac is more

than 6 cm. in length it is more or less tortuous in its course, and Thompson states that the length of the common iliac is somewhat greater in females and that the tendency in females is to bifurcate at a lower level. The number of females in this series is too small to make similar comparisons.

The length of the hypogastric artery varies considerably. Quain gives the average length of 2.5 to 4 cm.; Poirier, 2 to 4 cm. The observations in 181 dissections are as follows:

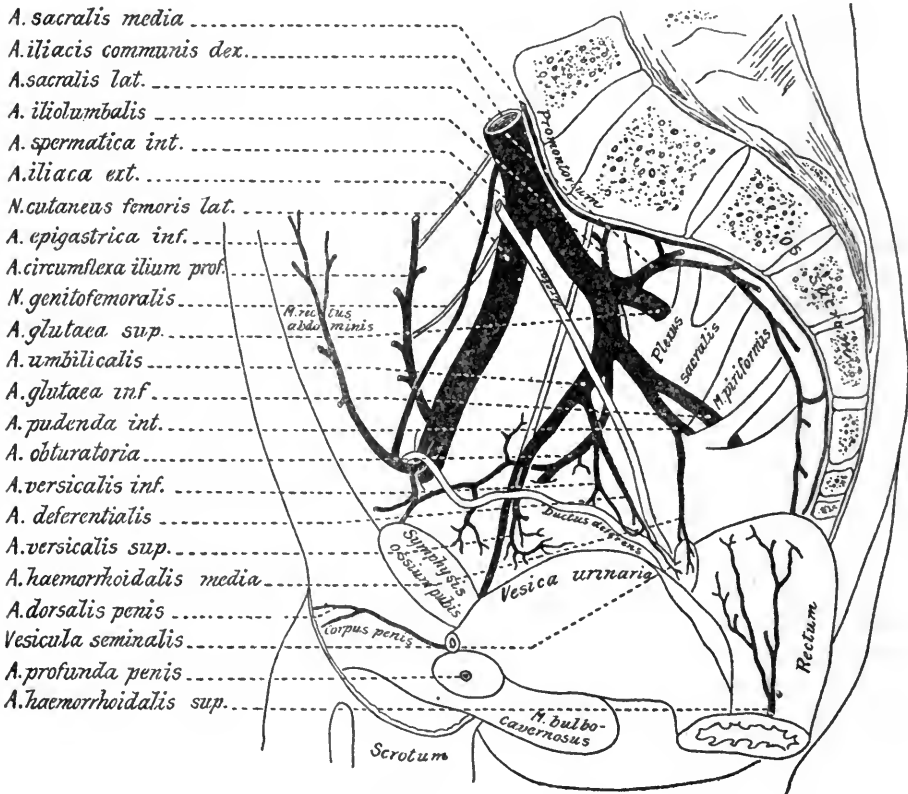


FIG. 1.—Type I occurs in 40 per cent. of the arteries studied.

	Number of arteries	Per cent.
1.5-2.5 cm. ....	24	13.5
2.5-3.5 cm. ....	50	28.0
3.5-4.5 cm. ....	67	37.6
4.5-5.5 cm. ....	20	11.2
5.5-6.7 cm. ....	17	9.5

It is worthy of note that if the aorta divides at a lower level, there is no shortening of the iliac or hypogastric arteries, the division of the latter vessels occurring at lower levels.

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## SECTION B—DESCRIPTION OF TYPES

TYPE I.—This type (Fig. 1) occurs in 40 per cent. of the cadavers studied, 24 per cent. on the right side of the body, and 16 per cent. on the left side. In this group the superior gluteal artery constitutes the largest branch and arises as the dorsal or posterior trunk of the hypogastric (internal iliac) artery; the internal pudendal (internal pudic) and the inferior gluteal arteries arise in a common trunk caudal to the superior gluteal.

The obturator, vesical, middle hemorrhoidal, and uterine arteries arise as separate branches from the caudal continuation of the hypogastric artery. The obturator

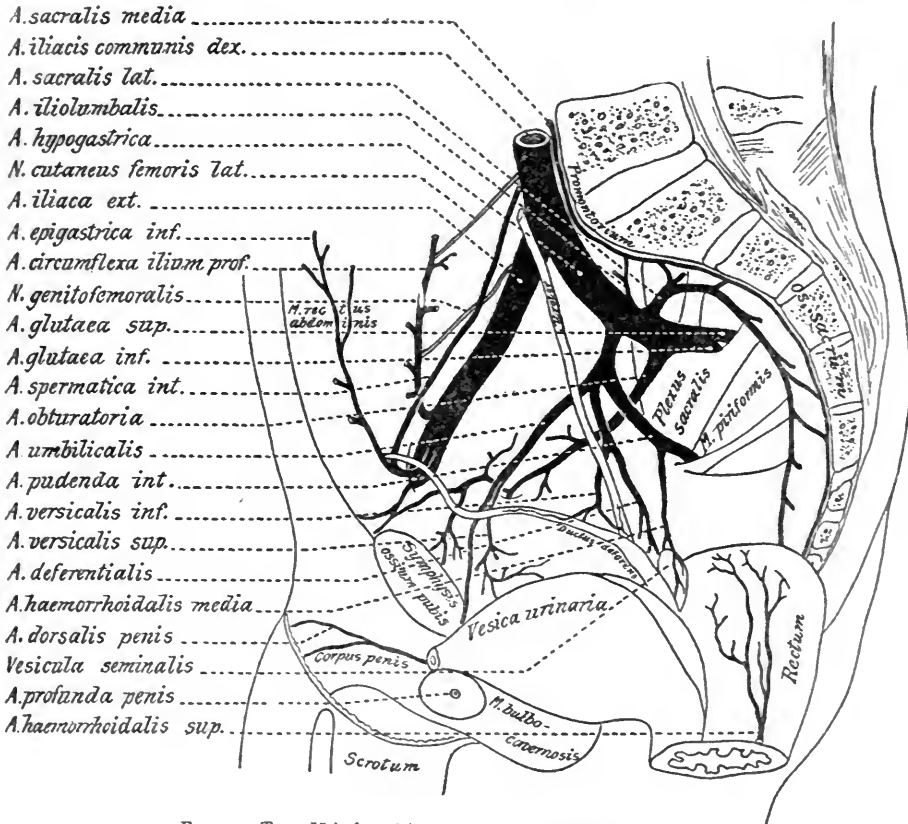


FIG. 2.—Type II is found in 24 per cent. of the arteries studied.

artery in 45 per cent. of the vessels of this group arises in a common trunk with the inferior (deep) epigastric artery from the external iliac.

The obturator artery arises 16 times as a separate branch from the superior gluteal artery. In one subject of this group the obturator is present as a branch of the femoral artery.

There are in this type 28 male white, 6 female white, 3 male negro, 1 female negro subjects. Jastschinski found this type present in 38 per cent. of the subjects classified, 20 per cent. on the right side of the body and 18 per cent. on the left side.

TYPE II.—This type (Fig. 2) occurs with slight variations in 24 per cent. of the vessels observed, 14 per cent. on the right side of the body, and 10 per cent. on the left side. The superior and inferior gluteal arteries arise from the hypogastric

(internal iliac) artery in a common trunk. The internal pudendal, obturator, and uterine arteries arise as separate branches from the caudal continuation of the hypogastric artery.

In 40 per cent. of the arteries of this group, the obturator artery arises as a separate branch from the common trunk of the superior and inferior gluteal arteries. The obturator artery occurs three times in this group in a common trunk with the inferior (deep) epigastric, which common trunk arises from the external iliac artery. In every case observed the common trunk for the superior and inferior gluteal arteries makes its exit from the pelvis by passing through the great sacrosacral foramen (foramen ischiadicum majus) cephalic to the pyriformis muscle (foramen suprapyriforme).

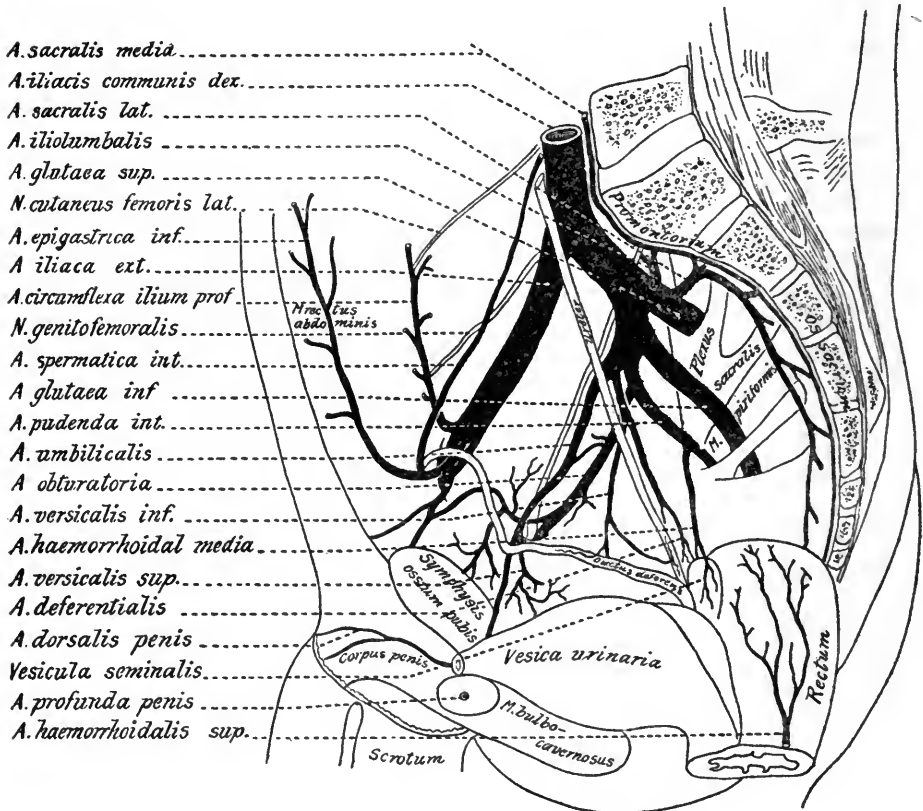


FIG. 3.—Type III occurs in 17 per cent. of the arteries studied.

The internal pudendal artery in two subjects of this group is present as a separate branch of the common trunk for the superior and inferior gluteal arteries after the trunk has made its exit from the pelvis.

There are in this type 22 subjects in all, 16 male white, 3 female white, 2 male negro, and 1 female negro.

TYPE III.—This type (Fig. 3) is found with slight variations in 17 per cent. of the arteries classified, 10 per cent. on the left side of the body and 7 per cent. on the right side. In this type the superior gluteal, inferior gluteal, and internal pudendal arteries occur as separate branches of the hypogastric artery. The obturator in this group is variable in its origin, occurring 17 times as a separate branch of the hypo-

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gastric artery, 4 times as a branch of the inferior gluteal, 5 times as a branch of the internal pudendal, 4 times in a trunk common with the inferior (deep) epigastric, and in two cases it is present as a branch of a large middle hemorrhoidal artery.

There are in this type 16 subjects in all, 14 male white, 1 female white, and 1 male negro.

TYPE IV.—This type (Fig. 4) is found in 11 per cent. of the arteries observed, 3 per cent. on the right side of the body and 8 per cent. on the left side. In this group the obturator, the internal pudendal, and the inferior gluteal arteries arise from the hypogastric artery in a common trunk. The superior gluteal artery arises as a sepa-

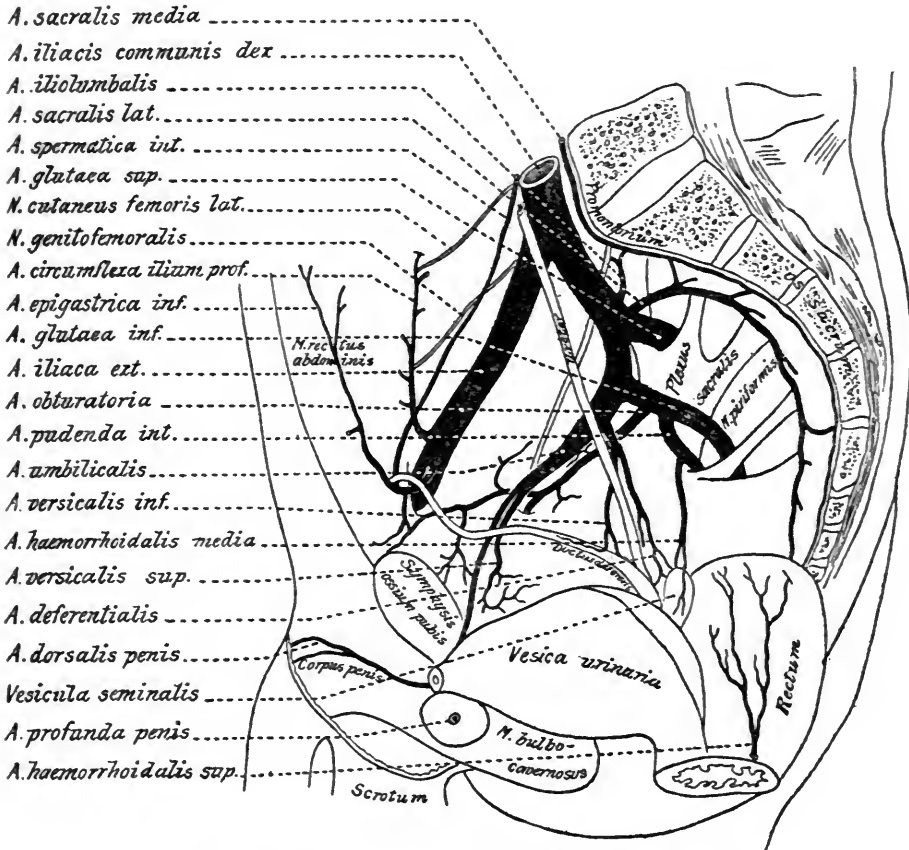


FIG. 4.—Type IV occurs in 11 per cent. of the arteries studied.

rate branch dorsal to the trunk for the inferior gluteal, obturator, and internal pudendal arteries.

The superior gluteal artery is usually larger than the trunk for the inferior gluteal, obturator and internal pudendal arteries. There are in this type 11 subjects in all, 8 male white, 1 female white, 1 male negro, and 1 female negro.

TYPE V.—This type (Fig. 5) occurs in 7 per cent. of the arteries observed, 2 per cent. on the right side of the body and 5 per cent. on the left side. In this group the superior gluteal, inferior gluteal, obturator and internal pudendal arteries arise from the hypogastric artery in a common trunk. It is interesting to note in this connection that this group is represented wholly by male whites, 6 in all.

### SECTION C—DESCRIPTION OF BRANCHES

*A. obturatoria*: Probably no artery in the human body of proportionate size has so voluminous a literature as the obturator artery. It has been the subject of repeated anatomical research. Haller, in 1745, first observed and noted the origin of the obturator artery as a branch of the inferior epigastric. Murray and Portal recorded instances in which this vessel arises variously as a branch of the external iliac, femoral and inferior epigastric arteries. Monroe in 1805, Cooper in 1807, and Barclay in 1806 noted

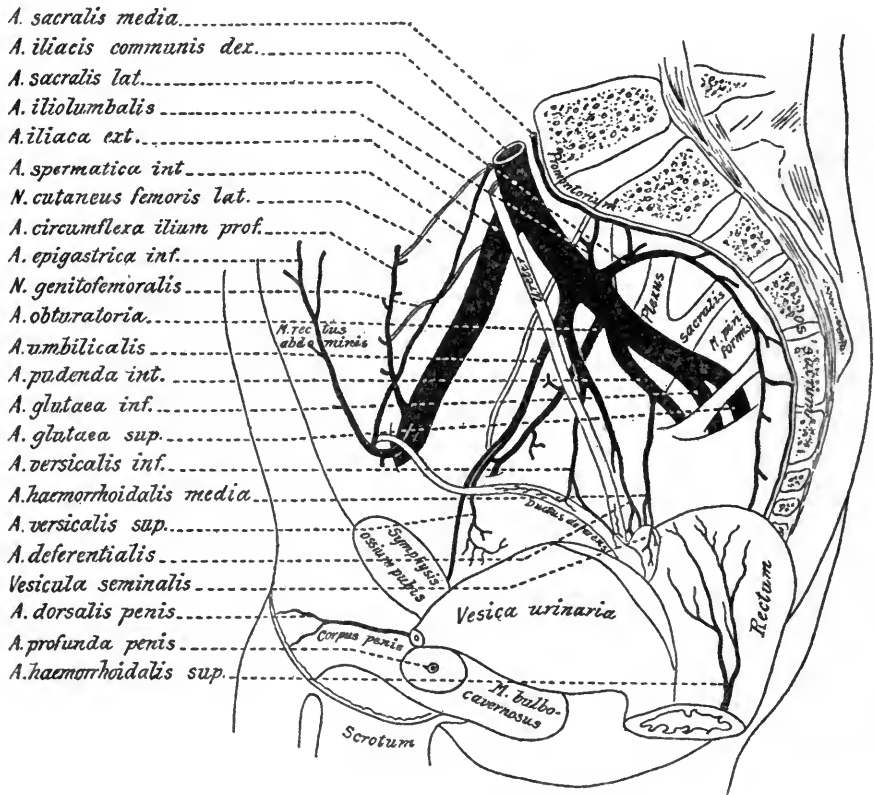


FIG. 5.—Type V occurs in 7 per cent. of the arteries studied.

anomalous obturator vessels coursing in relation to the free edge of the lacunar (Gimbernat's) ligament and their importance to femoral hernia.

The obturator artery presents considerable variation in its origin, size and distribution. It arises in a trunk common with the inferior epigastric in 19.3 per cent. of the cadavers studied. This variation occurs in 12 per cent. of the cadavers on the right side of the body, and in approximately 7 per cent. on the left side, and in 30 per cent. on both sides of the same body. The important statistics in literature as to the frequency of this variation are stated in the following table:



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	Number of bodies examined	Per cent.
Quain .....	400	31.9
Brochet .....	63	..
Cloquet .....	500	31.4
Hoffman .....	63	32.5
Pfitzer .....	307	37.6
Hesselbach .....	64	42.2
Krusche .....	63	21.2
Dwight .....	500	25.8
Jastschinski .....	404	24
Levi .....	100	25.2

The obturator artery arises 16 times (9 per cent.) as a separate branch of the superior gluteal artery; 5 times (3.5 per cent.) as a branch of the inferior gluteal; 7 times (4 per cent.) as a branch of the pudendal artery. The obturator artery arises 17 times (9.4 per cent.) as a separate branch from the common trunk for the superior and inferior gluteal arteries. In 10 per cent. of the subjects observed, this vessel is found in a common trunk with the superior and inferior gluteal arteries and in 7 per cent. in a common trunk with the superior gluteal, inferior gluteal, and internal pudendal arteries. It arises three times as a branch of the external iliac artery caudal to the origin of the inferior epigastric.

In two cases observed, it occurs as a branch of the femoral artery. Mention is made by the writer in the study of the femoral artery of the occurrence in two subjects of the obturator artery arising in a common trunk with the medial circumflex and inferior epigastric arteries, which trunk takes origin from the external iliac. This unusual variation was not observed in this series.

The obturator arises in two stems which unite to form a single obturator artery in 11 of the cases observed. In six of the subjects of the latter group, one stem takes origin from the inferior epigastric artery and the other from the hypogastric artery. The obturator occurs three times as a twin vessel, both rami remaining independent. Jastschinski in study of 88 fœtuses states that the inferior epigastric artery rarely arises in two stems, and that the additional vessel is in reality another obturator artery.

The common trunk for the obturator and inferior epigastric arteries varies in length from 1 to 3 cm. The common origin of the obturator and the inferior epigastric is of importance since, in its course through the pelvis to the obturator canal, it is in close relation with the femoral (crural) ring (annulus femoralis). The femoral ring is above the inner opening of the obturator canal.

The relation of the obturator artery to the femoral ring varies as follows:

1. If it arises from the external iliac artery it bears little or no relation to the femoral region.

2. If it arises from the femoral artery it usually courses between the femoral vein and the lacunar (Gimbernat's) ligament, usually dorsal and caudal to the femoral ring. In about one-half of the recorded cases in

literature the obturator artery courses along the outer half or two-thirds of the femoral ring, in the latter position it is most likely to be injured and result in dangerous hemorrhage. To avoid this injury the iliopubic ligament should be incised as near as possible to the lacunar ligament.

3. If it arises as a common trunk with the inferior epigastric, the relation of the obturator to the femoral ring varies—(a) if from the central portion of the artery between the external iliac artery and the inguinal ligament, or from the summit of the common trunk of the inferior epigastric and obturator arteries, it pursues an arched course and is usually related to the lateral border of the femoral ring; (b) if it arises at or above the inguinal ligament, it lies at the medial border or middle of the femoral ring. It is usually related to the lateral side of a femoral hernia. The obturator artery courses transversely across the hernia according to Jastschinski in 22 per cent. of the cases. The writer observed two cases in which the obturator artery courses transversely across the annulus femoralis. In female subjects the obturator artery courses more frequently along the lateral border of the femoral ring than the medial.

The ramus pubicus superior usually occurs as a branch of the inferior (deep) epigastric artery. Not infrequently this vessel arises from the inferior epigastric at the medial border of the femoral ring and frequently is of large calibre and easily injured in operative procedures, becoming a source of troublesome and dangerous hemorrhage. The obturator artery leaves the obturator canal and usually divides into two diverging branches, both of which course on the pelvic (ental) side of the obturator membrane between the latter and the obturator externus muscle. The ventral branch lies on the bone, the dorsal branch lies on the ectal surface of the obturator membrane. The ventral branch gives off a large number of small rami, some of which supply the obturator internus muscle. The obturator artery usually pierces the obturator canal and divides into two terminal branches, ramus anterior and posterior. The ramus anterior sends a branch to the symphysis pubis and then courses along the inferior ramus of the pubis. The ramus posterior usually gives off three branches; the ramus acetabular, the ramus internus to the medial surface of the obturator membrane, and the ramus externus which supplies the ischial nutrient arteries.

*Arteria prostatica:* This vessel varies in its course, origin and distribution. It arises in 10 per cent. of the cadavers observed as a branch of the middle hemorrhoidal, 5 times as a branch of the inferior gluteal, 15 times as a branch of the obturator, 10 times as a branch of the ischiopudendal trunk, and 30 times as a branch of the anterior trunk of the hypogastric artery after its division. It is also not infrequently present as a branch of the umbilical artery. Occasionally it arises in a common trunk with the inferior vesicle artery. The direction of the prostatic artery varies in accordance with its origin. The usual course is caudal, medial and ventral. The consideration of the prostatic artery as the trunk of origin for the profunda and dorsalis penis arteries will be described subsequently.

*Arteria vaginalis*: This vessel is the homologue of the prostatic artery in the male. It is frequently confused with the inferior vesicle artery. The vaginal artery is represented as a twin vessel in 40 per cent. of the female subjects of this series. This vessel may occur as a branch of (a) the inferior gluteal, (b) the ischiopudendal trunk, (c) the obturator, (d) the anterior trunk of the hypogastric and uterine arteries. The vaginal artery arises in two subjects in a common trunk with the middle hemorrhoidal.

In those subjects in which the vaginal is represented as a double vessel, the proximal artery is found either as a branch of the anterior trunk of the hypogastric, uterine or internal pudendal, the distal artery either from the internal pudendal, ischiopudendal trunk, obturator, inferior gluteal or in a common trunk with the middle hemorrhoidal.

The vaginal artery is distributed to the lateral surface of the vagina, the posterior surface being vascularized by the middle hemorrhoidal artery.

*A. glutea inferior (A. ischiadica)*: This vessel presents considerable variation in its course, origin and distribution.

The committee on collected statistics and investigations, in an observation of 50 cases, state that this vessel arises in 75 per cent. of the arteries recorded from the anterior trunk of the hypogastric artery, in 21.4 per cent. as a branch of the superior gluteal artery.

Cruveilhier and Sappey describe the inferior gluteal as arising either in a common trunk with the superior gluteal or internal pudendal arteries.

The inferior gluteal artery arises in a common trunk with the internal pudendal artery in 40 per cent. of the cases classified. The length of the ischiopudendal trunk varies from 2 to 8 cm. In 25 per cent. of the subjects in which this arterial trunk is present, it is from 6-8 cm. and divides into the internal pudendal and inferior gluteal arteries after its exit from the pelvis. This division occurs at or close to the sacrotuberous ligament under cover of, or at the lower margin of, the piriformis muscle, and at times 2-4 cm. caudal to the piriformis muscle. In approximately 30 per cent. of the subjects, the ischiopudendal trunk is from 0.02-2.5 cm. in length. The ischiopudendal trunk usually divides into the internal pudendal and inferior gluteal arteries in the pelvis; the internal pudendal artery occasionally arising from the ischiopudendal trunk within 1 cm. of the lateral margin of the sacrotuberous ligament. The inferior gluteal frequently takes a circuitous course at first medial to the internal pudendal artery, then crosses the latter vessel and has a position lateral to the (Fig. 6) internal pudendal artery and medial to the sciatic nerve.

The inferior gluteal artery arises, in 24 per cent. of the cadavers studied, in a common trunk with the superior gluteal artery. The inferior gluteal artery in these cases usually leaves the pelvis through the suprapiriforme, and is given off by the common trunk for the superior and inferior gluteal arteries at or just below the cephalic border of the piriformis muscle. Less frequently the inferior gluteal artery takes origin from the common trunk of the superior and inferior gluteal arteries, either in the pelvis or under cover

of the upper fibres of the piriformis muscle, leaving the pelvis through the foramen infrapiriforme. The inferior gluteal artery in 17 per cent. of the subjects studied is present as a separate branch of the anterior trunk of the hypogastric artery. In 10 per cent. of the subjects studied, it occurs in a common trunk with the internal pudendal and obturator arteries. In 7 per cent. of the subjects studied the inferior gluteal artery is found in a common trunk with the superior gluteal, obturator and internal pudendal arteries.

The inferior gluteal artery is represented by two vessels, each having a separate origin in 16 per cent. of the arteries observed; both inferior gluteal arteries arise from the ischiopudendal trunk ten times. One inferior gluteal

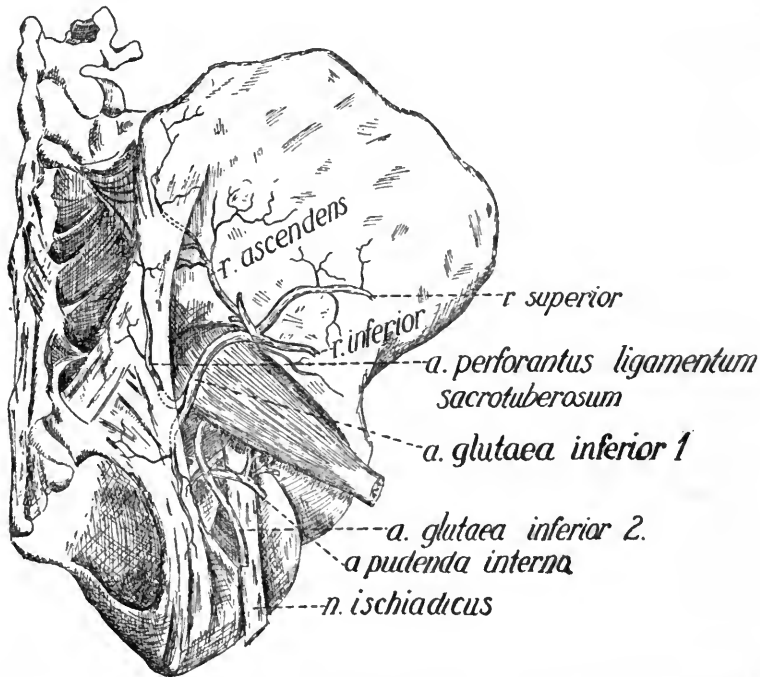


FIG. 6.—Type VI illustrates the occurrence of the inferior gluteal artery as a twin vessel. It also illustrates the usual relations of the sciatic nerve, inferior gluteal artery and internal pudendal artery.

artery arises as a branch of the anterior trunk of the hypogastric artery or in a common trunk with the internal pudendal, the other as a branch of the superior gluteal twelve times (Fig. 6). Both inferior gluteal arteries arise from the superior gluteal in nine of the cases. In three of the subjects studied, one inferior gluteal artery is present as a branch of the ischiopudendal trunk, the other as a branch of the obturator artery.

The inferior gluteal is usually dorsal, cephalic and medial to the internal pudendal artery in the pelvis.

Poirier describes four terminal branches: (a) R. posterior internus, (b) R. posterior externus, (c) R. inferior externus, (d) R. inferior internus,

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which is the dorsal and caudal continuation of the main stem of the artery. I have used the nomenclature of Poirier in the description of the terminal branches of the inferior gluteal artery.

The inferior gluteal artery is at times the trunk of origin of the obturator, middle hemorrhoidal, prostatic and vaginal arteries. The extrapelvic are, however, the more conspicuous branches of this vessel.

*Ramus posterior internus (Arteria perforans ligamentum sacrotuberosum)*: This vessel is usually well marked and of large calibre. It arises under cover of the piriformis muscle, courses medially and cephalically between the fibrous planes of the sacrotuberous ligament and here redivides and arborizes and occasionally reaches the sacrum. The branches perforate the sacrotuberous ligament and terminate either in the ligament or in the gluteus maximus muscle.

The number of arteries to the sacrotuberous ligament varies from 1 to 4 and the point of origin is variable. In 19 per cent. of the cases it arises at the caudal margin of the piriformis, close to the lateral margin of the sacrotuberous ligament. It frequently divides before it enters the fibrous planes of the ligament. When the perforating arteries are 3 to 4 in number they enter the ligament immediately cephalic to the spine of the ischium.

In those subjects in which the inferior gluteal is represented as a double vessel, one of the latter usually becomes the A. perforans ligamentum sacrotuberosum. The perforating artery also occurs as a separate branch of the hypogastric artery or in a common trunk with the internal pudendal artery. It is also found as a branch of the obturator or superior gluteal arteries.

*Ramus posterior externus*: This vessel is not constant and presents considerable variation in its point of origin and number. It arises frequently from 2 to 4 cm. from the caudal margin of the piriformis muscle. The vessel gives branches to the gluteus maximus, piriformis, gemelli, and quadratus femoris muscles.

*Ramus inferior internus*: This is not infrequently a well marked vessel. As it descends between the gluteus maximus and tuberosity of the ischium it divides into 2 to 4 branches, terminating close to the caudal margin of the gluteus maximus muscle.

*Ramus inferior externus*: This vessel is of larger calibre than the R. inferior internus and is the caudal continuation of the inferior gluteal artery. It is usually medial to the posterior femoral cutaneous (lesser sciatic) nerve or between the posterior femoral cutaneous and the ischiadic (great sciatic) nerves. This vessel not infrequently pierces the sciatic nerve, separates its fibres and becomes ensheathed by the fascia covering the nerve. In its course it gives rami to the quadratus femoris, gemelli, and adductor magnus muscles. The A. comitans nervi ischiadici is essentially this vessel, or the latter occurs as a descending branch. In very rare instances the A. comitans nervi ischiadici is an artery of large calibre and is the principal vessel of the thigh, retaining its connection with the popliteal

artery. This anomaly is described by the writer in the study of the femoral artery.

*Arteria iliolumbalis:* Cruveilhier considers this vessel as a branch of the hypogastric artery, although frequently arising from the superior gluteal, as stated by Theile and Henle. This vessel is found in 38 per cent. of the cases studied as a branch of the superior gluteal and in 52 per cent. as a separate branch from the hypogastric artery. The distance between the origin of the iliolumbar artery and the origin of the superior gluteal is variable, in 60 per cent. of the subjects it is 1 to 1.5 cm., in the remaining subjects it varies from 1.5 to 3 cm., the latter distance is found only 6 times.

The iliolumbar artery occurs 3 times as a separate branch of the anterior trunk of the hypogastric artery; 4 times as a branch of the common iliac artery, and in 2 cases as a branch of the external iliac artery. It also arises 6 times from the hypogastric artery in a common trunk with the lateral sacral. It is found absent in 5 subjects, and in these cases it is replaced by the fourth lumbar. An additional small lumbar artery is found 18 times.

The iliolumbar artery usually divides into its terminal branches from 1 to 2.5 cm. from its origin. It usually divides into two terminal branches, less frequently into three—the ramus lumbalis or ascending branch and the ramus iliacus or transverse branch. The ramus lumbalis and ramus iliacus arise as separate branches in 18 per cent. of the cases observed.

*Arteria sacralis lateralis:* These vessels vary in calibre, number and distribution. There are usually two lateral sacral arteries on each side of the body. In 51 per cent. of the cases classified, the sacral arteries arise in a common trunk. In 10 per cent. of the arteries studied three sacral arteries are observed; the additional vessel usually enters the second sacral foramen as a separate branch. The superior lateral sacral artery gives origin to the spinal branch, which enters the first sacral foramen; the inferior lateral sacral artery gives origin to the spinal branches which enter the second, third and fourth sacral foramina.

In those subjects in which the lateral sacral arteries are found to arise in a common trunk, the latter single trunk arises in 88 per cent. of the subjects from the superior gluteal artery and in 12 per cent. from the hypogastric artery. Its origin is always caudal to the origin of the iliolumbar artery. The lateral sacral arteries arise six times in a trunk common with the iliolumbar.

*Arteria glutea superior:* Cruveilhier and Theile describe this vessel as representing the direct continuation of the hypogastric artery. This vessel is the largest branch of the hypogastric artery. Its calibre is usually larger than the combined calibre of all the other branches of the hypogastric artery. The superior gluteal artery arises in 24 per cent. of the subjects studied in a common trunk with the inferior gluteal artery. The obturator artery arises sixteen times as a branch of the superior gluteal. In 7 per cent. of the cadavers studied, the superior gluteal artery arises in a common stem with the obturator, internal pudendal and inferior gluteal (sciatic) arteries. The

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iliolumbar artery in 31 per cent. of the vessels observed occurs as a separate branch arising from the superior gluteal. The stem of the superior gluteal gives origin to lateral sacral arteries in 88 per cent. of the cases classified.

The superior gluteal artery in 80 per cent. of the subjects observed passes outward between the lumbosacral trunk and the first sacral nerve. In the remaining subjects it courses lateralward and somewhat caudalward to the lumbosacral trunk. This vessel makes its exit from the pelvis through the great sacrosclatic foramen (foramen ischiadicum majus) cephalic to the pyriformis muscle (foramen suprapyriforme).

As it passes above the pyriformis muscle it is rarely of any length, never more than 1 cm., and divides immediately at its emergence into 2 to 4 large arborescent branches. In 10 per cent. of the subjects observed, it divides into 5 or 6 terminal rami.

The ramus superior of the superior gluteal artery usually ascends and divides into numerous smaller rami between the gluteus medius and the maximus, and the ramus inferior, the descending or deep branch, is constant and lies between the gluteus minimus and medius muscles. This branch divides again into transverse, lateral, and descending branches. The inferior ramus arises as a separate branch from the ramus superior in 16 per cent. of the cases classified.

*Arteria pudenda interna:* This vessel presents considerable variation in its origin, distribution and branches. It arises in 40 per cent. of the subjects observed in a common stem with the inferior gluteal artery; in 24 per cent. as a separate branch of anterior trunk of the hypogastric artery; in 17 per cent. in a common trunk with the obturator and inferior gluteal arteries, and in 7 per cent. in a common trunk with the superior gluteal, inferior gluteal, and obturator arteries. The internal pudendal artery is found in two subjects as a separate branch of the common trunk for the superior and inferior gluteal arteries after the common trunk has made its exit from the pelvis through the foramen suprapyriforme. The internal pudendal artery occurs four times as a branch of the middle hemorrhoidal and in two cases as a branch of the uterine artery. The internal pudendal artery usually has an intrapelvic course of 4 cm. The consideration of the branches of the internal pudendal arteries and their variations follows:

(a) *The arteria hemorrhoidalis inferior* (1 to 3 in number) pierces the obturator fascia and courses medially into the fat of the ischiorectal fossa. Cerf states that the terminal branches of the inferior hemorrhoidal arteries go to the cutis ani and to the portion of the rectum caudal to the levator and sphincter ani muscles. It vascularizes the external sphincter ani and the skin only.

The levator ani muscle is vascularized by separate branches which arise from either the inferior hemorrhoidal or from the internal pudendal under cover of the levator ani muscle. They are smaller than the hemorrhoidal vessels, meet the parietal wall of the rectum, enter the submucosa, ascend,

and at times anastomose with the superior hemorrhoidal arteries. This affirms the work of Waldeyer.

The inferior hemorrhoidal arteries occasionally take origin as branches from the inferior gluteal. When only one inferior hemorrhoidal artery is present it arises under the spine of the ischium. The second hemorrhoidal arises in 22 per cent. of the subjects from the perineal branch of the internal pudendal; arising from the latter vessel near its origin or in the perineum.

The artery to the obturator internus muscle arises as a separate branch from the internal pudendal or in a common trunk with the inferior hemorrhoidal. It anastomoses with the obturator or with the intrapelvic branches of the internal pudendal.

In the further description of the branches of the internal pudendal artery, the writer presents the latter vessel as dividing in the perineum into two terminal branches: (a) perineal artery (superficial perineal), so called because it courses through the superficial perineal interspace; (b) the deep perineal, which vessel courses through the deep perineal interspace between the layers of the triangular ligament, and in this part of its course gives origin to the urethral and bulbar arteries. The deep perineal artery continues forward and divides into two terminal branches: (a) A. profunda penis (artery to the corpus cavernosum) and (b) the A. dorsalis penis which reaches the dorsum of the penis by piercing the superficial layers of the triangular ligament.

(b) *Arteria perinei* (superficial perineal): This vessel usually arises caudal to the inferior hemorrhoidal. In 28 of the cases observed it is the terminal branch of the internal pudendal, the artery to the bulb and the penile artery then arising as branches of the prostatic artery. I have not been able to confirm the statement of Poirier who states that the perineal artery is larger in the female. The perineal artery courses over or under the superficial transversus perinei muscle in the superficial perineal interspace, becomes superficial, terminating on the posterior surface of the scrotum in the male and on the labia majora in the female. In three subjects the posterior scrotal artery is replaced by a branch of the external spermatic artery. The deep branch (A. transversus perinei) of this vessel courses transversely toward the median line, vascularizes the bulbocavernosus, ischio-cavernosus, the sphincter ani muscles and superficial muscles of the perineum, the vessel anastomosing with its fellow of the opposite side.

Waldeyer describes the perineal artery as giving the following branches: (a) Branch to ischiocavernosus; (b) skin of the perineum and inner side of the thigh (the latter may arise as a separate branch of the internal pudendal); (c) a vaginal branch to the vestibule (in 50 per cent. of the subjects); (d) a branch to the bulbus urethrae or bulbi vestibuli vaginæ (A. bulbi urethræ; bulbi vestibuli vaginæ). This vessel usually arises from the deep perineal artery between the layers of the triangular ligament and about  $\frac{1}{2}$  cm. above the level of the base of the trigonum urogenitale (triangular ligament). It is a large vessel in the male and courses transversely toward



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the median line and pierces the superficial layer of the triangular ligament. The branch to the bulb divides into a number of rami and gives off a ventral branch to the corpus cavernosum and a branch to the glandula bulbo-urethralia (Cowper's gland) and anastomoses with the bulbar artery of the opposite side.

This vessel arises 14 times as a branch of the prostatic artery. It occasionally occurs as a branch of the inferior hemorrhoidal artery. It arises as a separate branch from the perineal artery in 11 per cent. of the subjects. The bulbo-urethral artery is represented as a twin vessel twelve times.

*Arteria urethralis* (bulbourethralis of Kobalt) usually arises in the deep perineal interspace from the deep perineal artery ventral to the origin of the bulbar artery, pierces the superficial layer of the ligament and enters into the sulcus between the corpus cavernosa and corpus spongiosum. This vessel gives origin to one or two branches to the root of the corpus cavernosa, enters the corpora of the same side and courses to the glans penis and anastomoses with the dorsalis and profunda penis arteries.

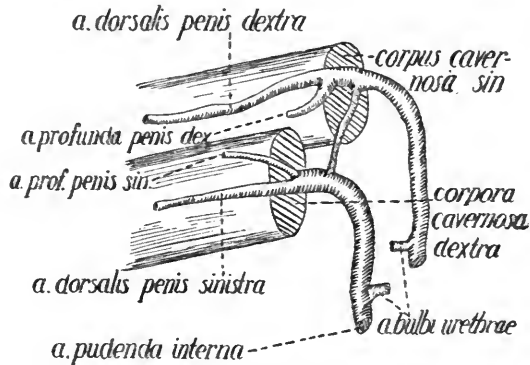


FIG. 7.—Illustrates the presence of an anastomotic branch between the dorsalis penis arteries dorsal to the origin of the profunda penis and occurs in 15 of the arteries studied. Figs. 7 to 11 illustrate unusual variations in the profunda and dorsalis penis arteries.

*Arteria dorsalis penis* (or *clitoris*): Cruveilhier and Poirier consider this vessel as the terminal artery of the internal pudendal. Henle and Sappey consider both the profunda penis and the dorsal artery of the penis as terminal arteries of the internal pudendal. The dorsalis penis artery is the continuation of the internal pudendal beyond the origin of the profunda penis. This vessel follows its usual course and distribution in only less than one-half of the cases observed. In the remaining subjects, it presents variation in its point of origin, in its branches and in the presence of anastomotic rami. Every artery observed in the latter group presents some variation; the latter are so numerous that I will only note the more important and conspicuous variations.

The arteriæ profunda penis and dorsalis penis are considered under a single heading because of their close relation.

An anastomotic branch is found between the dorsalis penis arteries dorsal (or proximal) (Fig. 7) to the origin of the profunda penis artery in

15 of the cases observed. This transverse anastomotic branch occurs three times ventral (or distal) (Fig. 8) to the origin of the profunda penis artery, and gives origin to a double left profunda penis; the right profunda penis arising as a branch from the right penile artery dorsal to the anastomotic branch. In one subject both profunda penis arteries unite and after a course of 1 cm. redivide again into the right and left profunda penis arteries.

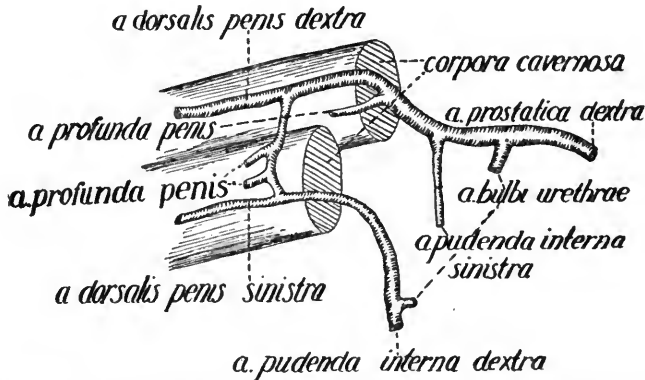


FIG. 8.—Represents the transverse anastomotic branch ventral to the profunda penis artery. This occurs in three subjects.

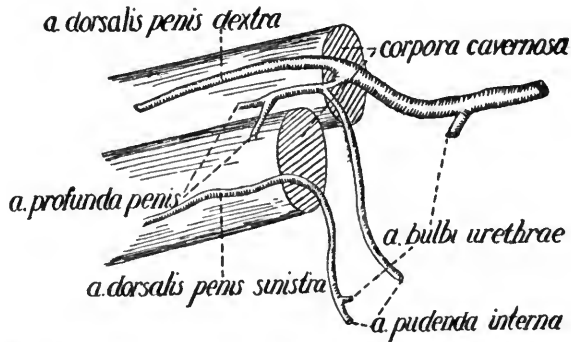


FIG. 9.—Represents the origin of the right dorsalis penis artery from the prostatic; and the former artery gives origin to a branch which is a common trunk for the right and left profunda penis arteries. This occurs in six of the subjects studied.

The right dorsalis penis artery arises from the right prostatic artery and gives origin to a branch which is a common trunk for the right and left profunda penis arteries (Fig. 9); the profunda of the left side is absent. This arrangement is found six times. An accessory profunda penis which arises from the inferior vesical occurs four times.

In two cases the left dorsalis penis artery arises from the inferior vesical artery (Fig. 10); in these subjects both profunda penis arteries arise in a common trunk from the internal pudendal artery. This common trunk presents an anastomotic branch with left penile artery which arises from the inferior vesical.

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In 5 subjects the right internal pudendal terminates as the profunda penis artery, in these subjects the left prostatic continues forward and gives origin to the right dorsalis penis artery, the trunk then divides into the left profunda and left dorsal penis arteries.

In 7 of the cases observed both profunda penis arteries redivide and have a bilateral distribution (Fig. 11).

The dorsalis penis arises in two of the cases observed as a branch of the obturator.

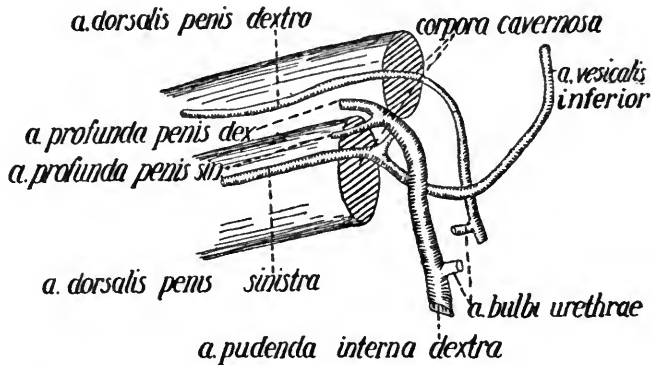


FIG. 10.—Represents the origin of the left dorsalis penis artery from the inferior vesicle. This occurs in two of the arteries studied.

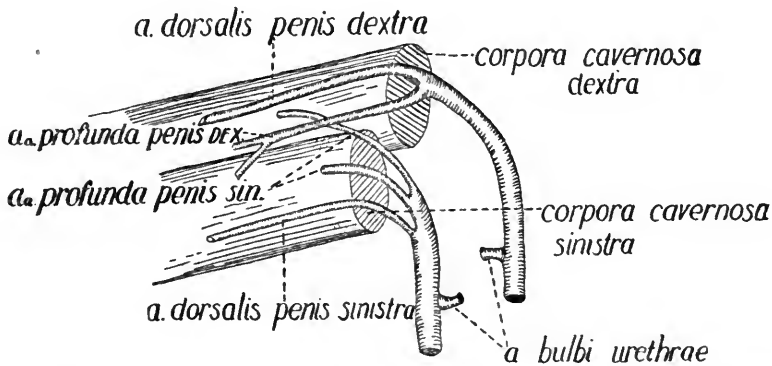


FIG. 11.—Represents both profunda penis arteries as having a bilateral distribution. This arrangement occurs seven times.

The middle hemorrhoidal and prostatic arteries are found frequently as branches of the internal pudendal.

Ischaussow has described several anomalies of the pudendal artery, 2 cases in which the penile artery arises from the obturator; 1 case in which the penile and bulbar arteries arise from the prostatic, the prostatic artery coursing lateral to the pelvic-prostatic capsule of Retzii. Wassiliew in 100 cases demonstrated in 19 anomalies of the penile artery; the latter vessel arises in two subjects from the obturator, 3 times as a branch of the vesiculo-

prostatic and in one subject from a proximal point in the normal pudendal artery. The course of the anomalous branch is always the same along the base of the bladder and prostate.

*Arteria hemorrhoidalis media:* This vessel is not constant. It is present in only 72 per cent. of the subjects observed. It varies in its calibre and origin. The middle hemorrhoidal artery arises most frequently as a branch of the internal pudendal. This origin occurs in 54 per cent. of the cases observed.

The *middle hemorrhoidal artery* arises 41 times as a branch of the inferior gluteal, 5 times as a branch of the obturator, 3 times as a branch of the vesiculodeferential artery and 3 times as a branch of the anterior trunk of the hypogastric artery.

In 15 per cent. of the subjects studied, this vessel is found double, the branches arising either from the internal pudendal or the anterior trunk of the hypogastric artery.

The middle hemorrhoidal not infrequently arises in a common stem with the vesiculodeferential artery, 10 times from the internal pudendal, 4 times from the inferior gluteal and 3 times from the anterior trunk of the hypogastric artery.

The blood supply of the middle hemorrhoidal to the rectum is not important. The principal blood supply of the rectum is the superior hemorrhoidal artery. Waldeyer affirms this anatomic fact. The anastomosis between the superior and inferior hemorrhoidal is submucous, that of the superior and middle hemorrhoidal subperitoneal.

The middle hemorrhoidal divides into 2 to 4 rami to the lateral parietes of the pelvis and gives small rami to the obturator internus, gemelli and pyriformis muscles, and in the female partly vascularizes the lateral and dorsal surfaces of the vagina.

*Arteria vesicalis inferior:* This vessel is not constant. It is found in only 70 per cent. of the subjects studied. Poirier describes this vessel as rising in a common trunk with prostatic, vesicodiferential or middle hemorrhoidal arteries.

The inferior vesical artery arises as a separate branch from the prostatic artery in 34 subjects studied. It occurs 3 times as a branch of the vaginal, 8 times as a branch of the umbilical distal to the uterine artery, 9 times as a branch of the vesiculodeferential artery, and 5 times as a branch of the internal pudendal artery.

This vessel occasionally replaces one or more of the branches of a defective internal pudendal artery; cases of this type are noted in a description of the latter vessel.

*Arteria deferentialis:* This vessel is homologous to the uterine in the female. It is constantly observed. It occurs most frequently as a branch of the anterior trunk of the hypogastric artery. This vessel is found 4 times as a branch of the middle hemorrhoidal, 3 times as a branch of the interior

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pubdental and in 2 subjects as a branch of the prostatic artery. The deferential artery occasionally replaces the internal spermatic artery.

*Arteria uterina:* The uterine artery is the homologue of the deferential artery in the male and arises more commonly second in order as a well-marked vessel from the ventral or anterior trunk of the hypogastric artery. This vessel occurs four times in a common trunk with the superior vesical artery; in two cases in a common trunk with the internal pudental and in one subject in a common trunk with the obturator. The uterine artery pursues a tortuous, medially directed course, insinuates itself between the layers of the broad ligament, and courses along its base. On approaching the neck of the uterus it usually divides into ascending branch running along the side of the uterus and a descending branch to the cervix. The ascending branch supplies the body of the uterus, and in this part of the course it gives off branches to the ventral and dorsal surfaces of the uterus which anastomose with the corresponding branches of the opposite uterine. The latter vessels diminish greatly in calibre as they pass forward to the medial line. The uterine artery usually gives origin to a branch to the fundus uteri; and two lateral branches: (a) Ramus tubarius, which anastomoses with the tubal branch of the ovarian artery; (b) a branch to the ovary (*R. ovarii*), which anastomoses with the ovarian. The latter branch gives a number of small branches to the broad ligament, which anastomose with the inferior epigastric. The uterine artery also gives off a number of small rami to ureter and bladder.

The uterine artery at its origin lies at a deeper level and lateral to the ureter. At the level of the spine of the ischium, the uterine artery enters the broad ligament to reach the uterus and in its course along the base of the broad ligament passes ventrad to the ureter.

The distance between the right and left ureters at the point of crossing between the ureter and uterine artery is from 6.5 to 7.5 cm., and 4 cm. at the level of the ostium externum uteri.

In one subject the uterine artery arises bilaterally in a common trunk with the internal pudental and at a more caudal level than the normal uterine; the uterine artery courses slightly lateral and dorsal to the ureter, and at the point of crossing, the uterine artery passes dorsal to the ureter.

This unusual relation of the ureter ventral to the uterine artery is evidently of the rarest occurrence. The writer could not find a single instance in the literature in which this anomalous relation was reported.

This unusual relation should be borne in mind by the surgeon in ligation of the uterine artery, in order that he may avoid injury to the ureter.

*Arteria vesicalis superior:* This vessel represents the persistence of the proximal end of the umbilical artery in the foetus. It arises four times in a common trunk with the uterine artery and also occurs in a common trunk with the vaginal and obturator arteries. The superior vesical artery divides into numerous branches (*Rami vesicales*) which supply the apex and body of the bladder and anastomose with the corresponding vessels of the opposite side.

## BENJAMIN LIPSHUTZ

### SECTION D—SUMMARY AND DISCUSSION

1. A comparison of the types of the arteria hypogastrica demonstrates the predominance of Type I on both sides of the body. This arrangement of the branches of the hypogastric artery occurs in 40 per cent. of the arteries studied, 24 per cent. on the right side of the body and 16 per cent. on the left side.

Type II occurs in 24 per cent. of the arteries observed, 14 per cent. on the right side and 10 per cent. on the left side; Type III in 17 per cent.; Type IV in 11 per cent. of the subjects, and Type V in 7 per cent.

A similar arrangement of the branches on each side of the body is present in 35 per cent. of the cadavers observed.

2. This study embraces the dissection of 93 cadavers: 72 male white, 11 female white, 7 male negro and 3 female negro. There are 91 dissections from the right side of the body and 90 dissections from the left side.

No relation of the branches to age could be drawn as there were only adults in this series. In the study of the femoral artery, the negro subjects presented a greater proportionate number of variations and anomalies than the white. Twelve per cent. of the dissections of this study were made on negro subjects. The latter subjects did not present proportionately a greater number of variations and anomalies. Unusual variations occur with greater frequency on the left side of the body.

3. Many of the variations which are found in studying the arterial tree in man, occur as normal types of vessels in lower forms. There is a normal type for each order. The careful comparative anatomy studies of Zuckerkandl and Popyski fail to disclose any well defined gradation of changes or laws upon which to base explanations of the genesis of variations. Tandler in his careful research and studies on the arteries of the head in animals affirms this anatomic fact, yet comparative anatomy appears to indicate that there has been a progressive change toward well defined types. It is reasonable to assume that in the higher mammals the arterial system is as complex as it is in man and that arterial variations occur with the same degree of frequency. This phase of the study of arterial variations—the explanation of their genesis on a comparative anatomy and embryologic basis, will be presented in detail in a later study.

4. The middle hemorrhoidal artery is found in 72 per cent. of the subjects observed. This vessel occurs most frequently as a branch of the internal pudendal (internal pudic) artery. The middle hemorrhoidal is frequently present as a separate branch arising from the inferior gluteal artery. In 15 per cent. of the subjects the middle hemorrhoidal is represented as a double vessel. The blood supply of the middle hemorrhoidal to the rectum is not important. The principal blood supply of the rectum is the superior hemorrhoidal artery. The anastomosis between superior and inferior hemorrhoidal is submucous, the anastomosis between the superior and middle hemorrhoidal arteries is subperitoneal. The middle hemorrhoidal also partly vascularizes the lateral and dorsal surfaces of the vagina. The vaginal

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artery usually vascularizes the lateral surface of the vagina. The vaginal artery is represented as a twin vessel in 40 per cent. of the subjects of this series.

The inferior gluteal artery arises in a common trunk with the superior gluteal artery in 24 per cent. of the arteries classified, the inferior gluteal artery in 40 per cent. of the arteries studied arises in a common trunk with the internal pudendal artery. This ischiopudendal trunk in 25 per cent. of the subjects divides into the inferior gluteal and internal pudendal arteries after it has made its exit from the pelvis.

The inferior gluteal artery in 16 per cent. of the cases observed is represented as a twin vessel, each of which has a separate origin.

The arteria perforans ligamentum sacrotuberum is one of the terminal branches of the inferior gluteal and is usually a vessel of large size, coursing between the fibrous layers of the sacrotuberous ligament. The R. inferior internus represents the caudal continuation of the inferior gluteal artery. This vessel not infrequently pierces the sciatic nerve, separating its nerve fibres and becomes ensheathed by the fascia covering the sciatic nerve.

The iliolumbar artery is found absent 5 times, in which subjects it is replaced by the fourth lumbar artery.

The superior gluteal is the largest branch of the hypogastric artery and in the adult is the direct continuation of the hypogastric artery. The superior gluteal artery courses between the lumbosacral trunk and first sacral nerve. This vessel makes its exit from the pelvis through the great sacro-sciatic foramen (foramen ischiadicum majus) cephalic to the pyriformis muscle, as it passes above the pyriformis muscle, it is rarely of any length, never more than 1 cm., and divides into a variable number of large arborescent branches.

The internal pudendal arises in 40 per cent. of the cases classified in a common trunk with the inferior gluteal artery; in 24 per cent. it arises as a separate branch from the anterior trunk of the hypogastric artery.

The internal pudendal terminates 28 times as the perineal artery, the prostatic replacing the vessels of the defective internal pudendal artery. Anastomosis between the penile arteries on both sides of the body is frequent in the male. The penile artery at times has a bilateral distribution. The dorsalis penis and profunda penis may arise from the prostatic artery, less frequently from the inferior vesical and obturator arteries. Approximately one-half of the dorsalis penis and profunda penis arteries present variations.

The obturator artery arises in a common trunk with the inferior epigastric artery in 19.3 per cent. of the subjects studied. The obturator arises not infrequently as a separate branch from the superior gluteal artery. The obturator artery occurs three times as a branch of the external iliac, and in two cases as a branch of the femoral artery. The obturator artery also occurs as a branch of the inferior gluteal artery, internal pudendal artery, the ischiopudendal trunk and the common trunk for the superior and in-

ferior gluteal arteries. The obturator artery is represented as a twin vessel in 11 of the cases observed.

The obturator artery varies in its relation to the femoral ring in accordance to its origin. 1. If it arises from the external iliac artery, it bears little or no relation to the femoral ring. 2. If it arises from the femoral artery and there is a hernia present, the obturator artery is usually caudal and dorsal to the femoral ring. In about one-half of the cases in which the obturator artery arises from the femoral artery, it is related to the outer half of the femoral ring and in this position it is likely to be injured and result in dangerous hemorrhage. To avoid this injury incise the iliopubic ligament as near as possible to the lacunar (Gimbernat's) ligament. 3. If it arises with deep epigastric artery, the relation of obturator artery to femoral ring varies in proportion to the height of its origin—(a) if it arises below (Poupart's) inguinal ligament, its course is lateral to the hernia; (b) if it arises above inguinal ligament, it pursues an arched course and is medial to the femoral ring. In a number of latter subjects, the obturator artery is lateral to the femoral ring.

The ramus pubicus superior arises occasionally at the inner edge of the femoral ring. This vessel is at times of large calibre and is easily injured in operative procedures in this anatomical region.

The aorta bifurcates most frequently at the level of the fourth lumbar vertebra.

The common iliac artery is usually from 4 to 6 cm. in length and divides most commonly between the fifth lumbar vertebra and the superior margin of the sacrum. The hypogastric artery varies in length from 2 to 5 cm. and its point of division varies from the superior margin of the sacrum to the upper border of the sacrosciatic foramen (foramen ischiadici majus).

The uterine artery usually arises from the anterior trunk of the hypogastric artery as its second branch. It enters the base of the broad ligament opposite the spine of the ischium, and in its course to the uterus passes ventrad to the ureter. This point of crossing occurs at the level of the ostium uteri interni. The right and left ureters are from 6 to 7.5 cm. distant from one another at the point of crossing and 4 cm. at the level of the ostium uteri externi.

In one subject the uterine artery arises on both sides of the body in a common trunk with the internal pudendal arteries. In the latter subject the uterine artery courses slightly lateral and dorsal to the ureter and at the point of crossing the uterine artery passes dorsal to the ureter. This unusual relation of the ureter being ventral to the uterine artery at the point of crossing is of the rarest occurrence, and should be borne in mind by the surgeon in ligation of the uterine artery, in order that he may avoid injury to the ureter.

Ellis, Eckhard and Ledwich have recorded cases in which the hypogastric (internal iliac) artery is absent on the left side of the body and its



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branches derived from a root of the external iliac artery dipping into the pelvis. This unusual variation is not observed in this study.

This study again illustrates the fact that the observation and classification of any one of the large arterial trunks of the body in a sufficiently extensive series of cadavers allow of a natural grouping into distinct types. The descriptions of the arterial trunks as contained in standard anatomical textbooks conform usually to but one type. The usual and accepted conventional opinion that whenever a vessel occurs which is at variance with a classic textbook description it is an anomaly, needs to be revised. In studying a large number of arteries of any one of the large arterial trunks, certain variations are found to occur with sufficient frequency to justify the establishment of distinct groups. At times variations occur which differ so widely from the normal types of the vessel that they cannot be classified, these alone should be termed anomalous. In the present study, every vessel observed conformed to one of the types. In the previous studies of the femoral and celiac axis arteries only less than two per cent. of the arteries observed were at variance to the described types.

This interesting phase of anatomical study—the establishment of anatomic types—brings together in a concrete and definite form all the possible variations of the particular artery. A knowledge of the types of the larger arterial trunks will aid the surgeon in avoiding troublesome and dangerous hemorrhage that otherwise could not be averted, and it is incumbent that he move slowly in operative procedures until he has determined the exact anatomy of the part. A constant variation in size, calibre and number of branches (defective arteriogenesis) is undoubtedly an etiological factor in the production of certain pathologic conditions.

My best thanks are due to Professor J. Parsons Schaeffer, Head of the Department of Anatomy, for his permission to make liberal use of all the material in his department and for his constant attention, interest and criticism in this study.

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## FRACTURE OF GREAT TOE SESAMOID BONES

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CASE REPORT.—In September, 1916, Doctor S., age about fifty years, while mowing his lawn, stepped on some hard object in the grass, causing a sharp, sudden pain beneath the right great toe at the metatarsophalangeal joint. He wore a shoe with a very thin sole, making indentation by a hard object very easy. The pain continued, when walking, more or less severe for two weeks. No swelling or redness was noted at any time, but there developed some thickening in the region beneath the joint. An X-ray taken at this time showed a transverse fracture of the right tibial sesamoid bone without separation of the fragments. Two weeks after the primary injury, while hunting doves, the patient stepped into a small post-hole, injuring the foot again in the same place. The post-hole was just large enough to catch the heel and toe of the shoe, hyperextending the great toe. The pain was so severe at this time that the patient dropped to the ground and was unable to bear any weight on the foot for several minutes. He later walked with difficulty for a half mile. No swelling or redness was noted at this time. Two weeks after the second injury, another radiograph was taken which showed a definite separation of the two fragments of the previously fractured bone (Fig. 1). The corresponding bone of the opposite foot was normal.

It was thirty days before any treatment was begun. There was more or less constant pain at the site of the fracture during this time. At the suggestion of Dr. W. J. Frick a large bunion plaster was strapped beneath the joint with adhesive. This treatment completely relieved the symptoms. For two weeks the patient used crutches, keeping the injured foot from the ground. For eight or ten weeks thereafter, he walked with a cane, stating that he was "always conscious that something was wrong" beneath the base of the great toe. Eleven months after injury there was still some pain when walking on rough, uneven ground. Eighteen months after the patient could walk without difficulty. There was no disability and he considered himself cured. The X-ray shows bony union between the two fragments (Fig. 2).

The sesamoid bones beneath the great toe are situated one in each head of the flexor brevis hallucis. The dorsal surfaces of the bones enter into the formation of the metatarsophalangeal joint. They are concave on the dorsal and convex on the ventral surface, and are joined together by fibrous tissue and the capsular ligament in such a manner that a groove is formed on the plantar surface for the passage of the flexor longus hallucis. The median, or tibial, bone is situated directly under the head of the first metatarsal and the lateral, or fibular, extends beyond the head laterally, as shown

by the radiograph. This anatomical difference may account for the more frequent fracture of the inner bone. The sesamoid bones beneath the great toe are the largest in the body, except the patella. These bones are constantly present and are a definite part of the human osseous structure. They are sometimes congenitally divided into two or more parts, especially the tibial sesamoid. A percentage as high as sixteen has been found in which one or more bones were divided in the examination of one hundred normal feet. The size of the bones has been given as 12 to 15 millimetres long by 9 to 11 millimetres wide for the tibial and 9 to 10 millimetres long by 7 to 9 millimetres wide for the lateral. The centres of ossification appear between the eleventh and fourteenth years.

TABLE OF REPORTED CASES OF FRACTURE OF THE GREAT TOE SESAMOID BONES

Reported by	Year	No. of cases	Bone fractured	Sex	Age	Direct or indirect violence
Schunke.....	1901	1	Right tibial	M	42	Direct
Marx.....	1904	1	Right tibial	M	40	Direct
Polak.....	1906	1				
Muskat.....	1906	1	Right fibular	M	50	Indirect
Momberg.....	1907	2	Right tibial	M	..	Direct
			Right tibial	M	..	Direct
Stumme.....	1908	2	Right tibial	M	..	Indirect
			Left tibial	M	40	Direct
Igelstein.....	1908	1	Right fibular	M	22	Direct
Morian.....	1909	5	Left tibial	M	32	Direct
			Left tibial	M	49	Direct
			Right tibial	M	30	Direct
			Left tibial	M	23	Direct
			Left tibial	M	14	Direct
Painter.....	1910	1	Right tibial and fibular	M	66	Direct
Royer.....	1911	1	Right fibular	M	..	Direct
Müller.....	1912	1	Left tibial	F	35	Direct
Speed.....	1914	5	Left fibular	M	..	Direct
			Left tibial	M	..	Direct
			Right tibial	M	..	Direct
			Right tibial	M		
			Right tibial	F		
Boardman.....	1915	1	Right tibial	F	25	Indirect
Eiken.....	1916	1	Right tibial	F	38	Direct

Fractures of the great toe sesamoids have, in a large percentage of instances, been produced by direct violence. A history of a weight falling on the dorsum of the foot, a squeezing or crushing injury, a fall from a height with greatest weight over the sesamoids, or a sudden increase in weight bearing are among the commonest etiological factors. The case here reported was, primarily, one of sudden increase in weight bearing produced by pushing a lawn mower. Cases are reported in which the injury was produced by indirect violence and it has been shown that the fracture can be produced experimentally by forcible hyperextension. The injury occurs more frequently in the male during the active period of life between the ages of twenty and fifty years. The youngest case reported was fourteen years of age and the oldest sixty-six. There have been 24 cases of fracture



FIG. 1.—Fracture of the tibial sesamoid.

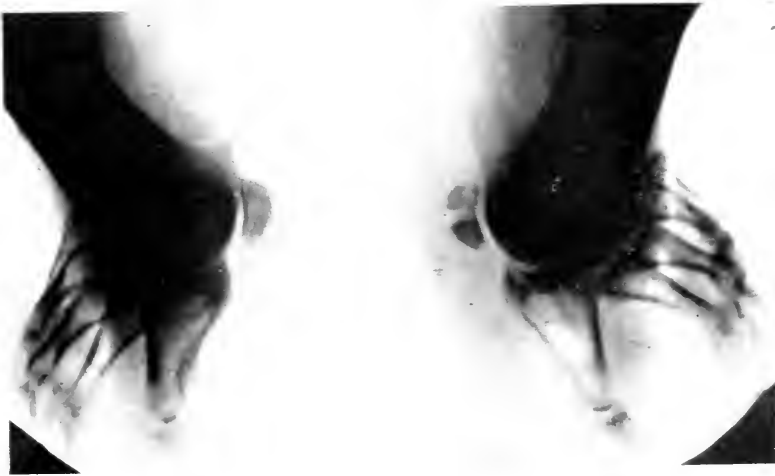


FIG. 2.—Same as Fig. 1, after bony union.



of the great toe sesamoids reported in the literature up to the present time. The accompanying table contains a list of the recorded cases.

Very little pathology is produced by the fracture alone. If the injury is produced by a weight falling upon the foot, there may be considerable trauma of the soft parts about the great toe. The fragments may be completely separated, but usually the separation is not great. There is often some inflammatory reaction about the joint with considerable thickening of tissue, especially on the plantar surface. Tenosynovitis in the sheath of the flexor brevis hallucis may develop.

The most pronounced primary symptom of fracture of the great toe sesamoids is sudden sharp pain at the time of the injury. This pain may be obscured by the more severe pain due to more extensive injury of the foot. There is some disability at once, the patient being unable to bear weight on that portion of the foot without pain. The disability may continue, more or less severe, over a long period of time unless satisfactory treatment is instituted. Tenderness in and about the great toe joint is generally quite marked, with often some swelling and, at times, redness. There is tenderness on palpation and pain on passive motion. Crepitus is rarely elicited.

The diagnosis of the condition is to be emphasized because of the frequency of mistakes. The fracture has frequently been considered a sprain or bruise and treated with liniments and hot fomentations. After a short rest the symptoms disappear and the patient is considered cured, only to have a recurrence when the use of the foot is resumed. A case is recorded of a nurse who was treated with a metal arch support by an orthopaedic surgeon, and later for rheumatism, by an internist. Congenital division of the bones must be carefully considered. Momborg has concluded that the cases reported by Schunke and Marx belong to this class. Igelstein thought his case might be one of congenital division. Painter's cases are also doubtful fractures. Several of the reported cases were not diagnosed for several months after the injury. The primary diagnoses that have been made have included almost all types of great toe joint disease from arthritis deformans to metatarsalgia.

The prognosis is good if the condition is recognized and properly treated. Some cases have complete bony union between the fragments. There may be considerable thickening at the site of the fracture with prolonged tenderness when weight is borne on the foot.

The best treatment, immediately after injury, is rest. Unless the rest is prolonged, it is usually not curative. The symptoms return in quite a large percentage of the cases when the use of the foot is resumed. The shoe can be constructed with a depression in the inner sole to relieve the pressure over the bone. A large bunion pad may be strapped beneath the joint with adhesive, as was done in the case reported. If, after reasonable conservative treatment, the part is still painful and causes disability, the fragments should be excised. When operation is necessary, it is advised by Speed that both sesamoid bones be removed, as it produces a better functional result.

LITERATURE

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Polak: Nederl Tijdschr. v. Geneesk., 1906, xlii, 954.  
Mombert: Deutsche Ztschr. f. Chir., 1907, lxxxvi, 382.  
Igelstein: Deutsche Ztschr. f. Chir., 1908, xciii, 505.  
Stumme: Fortschr. a. d. Geb. d. Röntgenstrahlen, 1909, xiii, 312.  
Morian: Deutsche Ztschr. f. Chir., 1909, cii, 387.  
Painter: Boston M. and S. J., 1910, clxiii, 362.  
Royer: Anjou med., Angers., 1911, xviii, 253.  
Müller: ANN. SURG., 1912, lv, 101.  
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Boardman: Surg., Gynec. and Obst., 1915, xxi, 394.  
Eiken: Hosp.-Tid., 1916, lix, 953.



# TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

*Stated Meeting, held December 3, 1917*

The President, DR. CHARLES H. FRAZIER, in the Chair

## OSTEO-ARTHRITIS FROM FOCAL INFECTION

DR. WILLIAM J. MERRILL presented a number of patients to demonstrate the relation between arthritis and tonsillar and dental infections. He prefaced the presentation of these patients by remarking that inflammations arising in joints, muscles, tendons, etc., are due to bacterial infections or intoxications or physiologic poisoning. The tissues in normal conditions, under normal and even abnormal stress, do not undergo any permanent pathological change. If the tone and resistance are diminished and the cells are irritated, slight stress produces morbid change in the parts which are weakest. The effects of traumatism in normal tissues are readily repaired and the tissues return to their normal condition readily, except when there is some constitutional disorder which keeps up the irritation. Arthritis from traumatism readily recovers except when there is a toxic or infectious agent present, under which condition the arthritis may remain subacute or chronic for a considerable time. Even in the case of dislocation or severe traumatism in which there is considerable solution of continuity, when poisons are not present, repair takes place readily. He had seen marked evidence of this fact within the past seven years, in which time mild and severe cases of arthritis have been noted to exist in the presence of focal infection and which have cleared up when the source of poison was eliminated.

Six and a half years ago, a severe case of hypertrophic osteo-arthritis of the hip-joint, in which there were already hyperostoses of the joint and limited motion in the hip-joint, recovered, and nearly normal motion returned after three teeth had been removed and the infection eliminated.

A large number of cases of "sacro-iliac relaxation," "sacro-iliac strain," "sacro-iliac sprain," etc., have recovered when nothing more was done than to treat the focal cause. Many cases of arthritis and localized inflammatory states in the spine are due to physiologic poisoning. From observation of these many cases of pain and tenderness in the spinal and pelvic structures, it has been proven conclusively that when any irritation is continued there is some bacterial or physiologic poisoning to "fan the flame"; furthermore, that in all irritation in a joint or other structure there must be a constitutional toxic state when the condition persists. In cases of mild pain in the sacro-iliac and lumbosacral structures, continued for a long time, and the severe prostrating attacks which might be termed "sacro-iliac crises," the evidence has been in many hundreds of cases very conclusive that the

condition was due primarily, as a predisposing cause, to systemic poisoning, and secondarily, as an exciting cause, to traumatism.

It is not possible to determine from the external appearance of a tooth whether it is infected or not, since many teeth are apparently not devitalized but are in the first stages of the infected condition. The tooth is infected by the invasion of bacteria to the root canal, which may take place by means of erosion through the dentine or enamel, which is chemical dissolution, or by means of abrasion, which is mechanical dissolution. The process of erosion takes place especially in the sulci of the crown and at the neck of the tooth at the junction of the enamel and the pericementum under the margin of the gum. When the dentine is encroached upon, the dental tubuli are opened up and bacteria can pass directly into the tooth. If an abrasion or lesion takes place in the pericementum, then by continuity the infection may travel external to the dentine up to the apex of the tooth and enter the root canal. The formation of tartar underneath the gum is a very frequent cause of erosion. When organic matter is lodged in the margin of the gum, chemical and bacteriochemical action takes place, especially when traumatism is added. Bacterial plaques are formed which adhere to the tooth. Calcification takes place and tartar is formed. Under this tartar, erosion occurs.

When teeth have lost their normal whiteness or have become discolored, they are undoubtedly in the stage of early infection or totally devitalized. Such condition, often when there is no tenderness or pain, should be suspected. The teeth should be X-rayed. When the tooth is devitalized and the abscess involves not only the apex but more or less of the alveolus, it should be extracted. Pivots in the stumps and roots of devitalized teeth, especially when the root canal filling is incomplete, are very frequently sources of infection. Pyorrhœa, especially when it is superficial, does not necessarily cause any constitutional disturbances because, as a rule, under this condition, there is no absorption and the pus which collects and is swallowed is unquestionably neutralized in the stomach.

Focal infections in the tonsils, nasal cavities, sinuses, along the intestinal tracts, such as infected glands, appendix, gall-bladder, in the genito-urinary tract, such as prostatitis, seminal vesiculitis, infected tubes, etc., are unquestionably frequent causes of various forms of arthritis.

DR. WALTER G. ELMER confirmed the statement that infection about a tooth can be disseminated throughout the body and cause serious difficulty. At one time he was himself apparently the victim of faulty dentistry. A week or two after a filling had been removed he began to have pain in the whole upper jawbone, and bore with it as patiently as possible for about three months. As the pain grew steadily worse instead of better he consulted another dentist who drilled through the filling, and about a thimbleful of pus escaped. There was instant relief. It was a front tooth and the pus had evidently burrowed over the upper surface of the hard palate. This is a typical instance in which the local infection may cause serious disturbance elsewhere, as in a joint which had received some slight traumatism.

## OSTEO-ARTHRITIS FROM FOCAL INFECTION

On the other hand, a certain amount of conservatism should be used. He related the experience of a friend who, during a visit to another city where great interest and enthusiasm were shown in tooth infection, was persuaded to have X-ray pictures made of his teeth. He was in perfectly good health and, so far as he knew, his teeth were in excellent condition and caused him no trouble whatever. But it was concluded from the X-ray films that he had seven teeth with abscesses at the roots and he was urged to have them extracted at once; otherwise he was marching straight to his doom! However, he demurred, and returned to Philadelphia with all his teeth.

It would be interesting to determine in a series of about 5000 examinations how many gave evidence of certain shadows indicating foci of infection at the roots of the teeth. An inflammatory process in the pericementum at the root of a tooth may subside entirely, leaving behind it only clean healthy tissue, and yet this area will cast a shadow of different density from that one in which there has never been any inflammatory process. Even a circumscribed abscess may become absolutely sterile. It often happens that no culture can be obtained from an old pyosalpinx. And yet such a condition at the root of a tooth would cast its shadow on the film. Children who have had their teeth straightened show changes in the density of the shadows about the roots, but that does not mean infection there because there never has been any infection. It is due to the shift in the position of the root.

A very large proportion of people must have these evidences who are nevertheless enjoying good health. The subject must be viewed in that light and not without caution. Perhaps in the conduct of the orthopædic clinics sufficient attention may not be given to the teeth, but a large number of the joint conditions improve under the usual methods of treatment without having teeth extracted. There are two sides to the question: one in which the matter is overestimated, the other in which the teeth are neglected altogether.

DR. MERRILL, in closing, remarked that patients are always carefully examined in the dispensary. If there is any suspicion of trouble in the mouth, they are sent to the Dental School. Practically 100 per cent. who have been sent to the Dental Clinic have had some mouth lesion. What the percentage of persons not examined in this manner is, it is impossible to state. In regard to ignoring the evidence given by X-ray, it is unquestionably an unwise attitude, even though in certain cases of marked caries of teeth and of the alveolus there is often but little trouble, since the "fires have burned out." Again the X-ray may not show any absorption, erosion or abscess because it is too small to cast a shadow.

In several cases, X-rays have indicated a large amount of erosion and absorption and that the cavities were filled with pus. On extraction there was practically no free pus but infection was present. The associated disabilities which we practically always find act as our guide, and as a rule the affected teeth which are the predisposing cause are extracted.

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A frequent cause of trouble which is not evident on inspection or X-ray examination is a small abscess at the roots of the tooth. The period when the infection is most likely to take place is in the beginning of the formation of this abscess. With these facts in mind, the importance of careful and repeated search is emphasized. If the abscess is not shown by the X-ray taken in a given angle, it should be taken at various angles with a hope of finding the pus cavity. Many times it will be hidden behind the apex of a root and not show. In certain cases referred to, in which there were decided symptoms, such as nerve pain and joint conditions, the abscess at the apex of the extracted tooth was about the size of a pinhead.

The symptoms have subsided in practically every case which was treated at the Dental Hospital, or at least at the present writing, cases which returned to the dispensary have shown improvement or cure. It is, of course, impossible to state the percentage of persons who have apical or alveolar abscess and are apparently in good health.

### SURGERY OF SPASTIC PARALYSIS

DR. A. BRUCE GILL read a paper with the above title, for which see page 529.

DR. GWILYM G. DAVIS said that he thought that the operation on the brain for the localized traumatism resulting in paralyzes did not originate from Doctor Sharpe's suggestion, but rather from Cushing's. He had been over the same material mentioned by Doctor Gill in reference to the examination of the eyeground. Cerebral decompression is obviously a measure intended to lessen the pressure inside the skull, and one of the symptoms of such pressure is clouding of the optic nerve as observed by the ophthalmoscope and that is what one universally fails to find. A child with spastic paralysis, even at the age of two years, does not have the use of the limbs which it should have at that period. The condition is called cerebral spastic paralysis and is often associated with an impaired mentality. Some of the evidences of that are very obscure and interesting. In the treatment of the cases, the old method of tenotomy still continues largely in force for two reasons: (1) the ease of its performance, its availability, and (2) because at times the results which it yields apparently compare favorably with those of other methods. He was not willing to go quite so far as does Doctor Gill in the advocacy of the Stoeffel operation, for his experience with it has not been so entirely favorable as his. He had not found it always an easy operation, being considerably more difficult than the tenotomies. He, too, had done it on two sides, but the difference has not been so great as to incline him on all occasions to prefer it to the tenotomy. It should be emphasized that by tenotomies and transplanting the condition in many of the cases can be improved. Doctor Nutt, of New York, some years ago divided the sciatic nerve deliberately, paralyzing the limb. He noticed considerable improvement in his patient, both in the parts affected and in the intelligence of the child. Encouraged by his results Doctor Davis divided the median nerve in

the case of a young woman of eighteen years with contracted arm. She improved to such an extent that she later wanted the nerve divided a second time. Arrangements were made to do this but the patient's husband objected and the operation was not done. The Stoeffel operation would be followed by considerable improvement. He did not wish to appear antagonistic to this operative procedure because he believed it to be a good one. There are cases, however, such as children who rise a little too much on the toes when they walk or run, in which cure is effected by simple tenotomy and without the necessity of the more elaborate operative procedure. Yet there is a field for the Stoeffel operation.

DR. CHARLES H. FRAZIER remarked, with reference to resection of the posterior roots for the treatment of spasticity, there is no doubt that the operation is a very serious one and that the mortality is relatively high; there is no doubt also that there has been a considerable number of failures. It is easier to give the contra-indications for the operation than to give the indications. Certainly the operation should not be done in subjects not physically strong, in delicate children, nor in feeble adults. It should not be done for spasticity in the upper extremities. It should not be done when there is lacking good muscular reserve power, for when the spasticity is relieved, the function restored in the way of locomotion will not be sufficient to have warranted an operation of that gravity. It should not be done in children who are mentally defective, because the after-treatment is essential, no matter what the operation be, and unless the surgeon is assured of coöperation on the part of the patient the results will not only not be good but in most instances a failure.

Now with regard to the technic of the operation, he emphasized the point, that in the early stages there were many failures because too few roots were cut. For complete and reliable statements of what can be done by this operation he referred to Förster's own writings. He has done more root resections for spasticity than any other surgeon, and has been more painstaking in the follow-up treatment. The end-results depend upon the care in the selection of the roots to be cut and the persistence of the after-treatment. Förster's articles are profusely illustrated and afford an excellent demonstration of what can be accomplished.

The operation itself is attended with a risk greater than that of the ordinary laminectomy because one is dealing chiefly with large bundles of sensory roots and any insult to these must be a predisposing factor in the causation of shock or collapse. He had found that by the application to the cord and roots at the level of operation of a cotton pledget, saturated with a 0.4 stovain solution, shock could be eliminated. This is a simple procedure and it seems entirely rational. As a matter of fact he had proven by pulse and blood-pressure tracings its efficiency in the experimental laboratory.

Another point of great moment in the technic is the question of post-operative bleeding. A small artery accompanies each root and if we are

content with the mere section of the root with knife or scissors there will always be more or less postoperative oozing. A very little blood inside the dural sac will result in the formation of adhesions. Absolute hæmostasis is essential to the ideal operation. This can be applied with reference to root resection by ligation; in fact, he had done some of these operations without cutting the roots at all. With the finest silk suture he simply tied the ligature around the root. The root must undergo degeneration; regeneration cannot take place in the root any more than it can in the spinal cord or brain. By applying two ligatures and dividing the root between, the operation can also be made bloodless.

Theoretically, the operation is based upon sound physiological principles, but the technic is too difficult to warrant one's recommending it except to the neurological surgeon. Its successful performance requires great technical skill and dexterity and the mastery of many important manœuvres with which only those accustomed to the surgery of the central nervous system are familiar. With these restrictions he earnestly endorsed the operation in selected cases, and had practised it a number of times in his clinic.

From what Doctor Gill has said and from his own knowledge of the subject there is no doubt that the Stoeffel operation has a very much wider application. The principle of the Stoeffel operation is fascinating. His first experience with it was in the laboratory. In trying to devise an operation for the relief of deltoid paralysis, one of the most common sequelæ of infantile palsy and particularly deforming and undesirable in young women, it occurred to him that it might be possible and feasible to sacrifice a portion of the function of the triceps muscle for the benefit of the deltoid, using for this purpose a portion of the musculospiral nerve, representing the innervation of the triceps muscle. Extremely painstaking dissections were made in the cadavers of monkeys, newborn infants, and adults. With these he was able to confirm the observations of Stoeffel and at the same time familiarize himself with the topographical anatomy of the musculospiral nerves. In two monkeys he carried out an end-to-end anastomosis of the intentionally cut circumflex nerve with the electrically isolated portion of the musculospiral nerve. (In the monkey this represents approximately the posterior third of this nerve.) Immediately after the operation there seemed to be a complete musculospiral palsy with wrist-drop and inability to abduct the upper extremity. At the end of five months the wrist drop had disappeared and movements of the upper extremity were quite unrestrained. This was his first experience with the Stoeffel principle and it was sufficiently positive to convince him of its physiological soundness and the practicability of its application. So far as the effect of cerebral decompression is concerned in the treatment of spasticity he said that in the beginning he viewed the proposition with absolute skepticism and that nothing he had heard since had led him to change his views.

#### MASSIVE DEGENERATION OF THE KIDNEY AND ITS RÔLE IN THE CLINICAL CURE OF RENAL TUBERCULOSIS

DR. ALEXANDER RANDALL read a paper with the above title.

TRANSACTIONS  
OF THE  
NEW YORK SURGICAL SOCIETY

*Stated Meeting, Held January 23, 1918*

The Vice-President, DR. WILLIAM A. DOWNES, in the Chair

INJURY TO THE COMMON BILE-DUCT

DR. WM. A. DOWNES presented a man, forty-two years of age, who was admitted to St. Luke's Hospital November 30, 1917, with the history of gall-bladder disease during one year. There was tenderness in the region of the gall-bladder, but no jaundice, and no history of chills or fever.

*Operation* (December 3, 1917).—On opening the abdomen the gall-bladder presented. Its wall was thickened and it contained a number of medium-sized stones—the ampulla seemed to be filled with a large quantity of very small stones. This part of the gall-bladder was freed easily and a clamp placed upon what was supposed to be the cystic duct and gall-bladder removed from within out. In the dissection a rather dense mass of adhesions was divided after the division of the supposed cystic duct had been made. It then dawned upon him that he had probably excised a portion of the common duct. Examination of the specimen disclosed the fact that the cystic duct was very short and entered the common duct obliquely, and that a section of the common duct three-quarters of an inch in length had been removed. An end-to-end suture was made. The posterior wall of the duct was fairly well approximated, but the anterior part did not come together very well. Drainage tube inserted up to the hepatic duct.

There was a profuse discharge of bile until January 6th—thirty-four days after operation. During the evening of this day the patient had a chill with a slight rise of temperature and vomiting. The next day drainage of bile became very scant, and from that time there has been no discharge of bile. The stools which had been bile-free immediately began to show presence of bile. Appetite and general condition have rapidly improved and temperature has remained normal.

The object in presenting this case is twofold. It illustrates the danger of injury to the common duct if one does not use ordinary care in isolating the cystic duct before placing the clamp. Second, it shows that the common duct regenerates in a short period of time (thirty-four days in this case), provided it is approximated in at least half of its circumference.

DR. HOWARD LILIENTHAL acknowledged having had a somewhat similar case where, in spite of most careful dissection of the gall-bladder, the bile-duct was tied off by mistake for the cystic duct. This was not dis-

covered at the time of operation, but later the patient became markedly jaundiced and died. Since this experience he has always taken the precaution to use a small, easily absorbable ligature in ligating the cystic duct, thus permitting a discharge of bile externally and a possibility of a reestablishment of the canal.

DR. ROBERT T. MORRIS brought up the question as to whether or not it was necessary to suture the cut ends of the common bile-duct, referring to cases in which he had removed a gall-stone impacted in the common duct and left the duct widely open; he considers this method worthy of consideration in cases where it is difficult or well-nigh impossible to suture the cut ends of the duct. He cited a case seen in consultation after removal of the gall-bladder because of the patient being badly jaundiced, and in which an immediate secondary operation disclosed the fact that the operator had ligated a knuckle of the common duct, thus cutting off the duct completely; the ligature was of absorbable catgut and the condition would have remedied itself in time without operation, but at the time of the exploration the patient was suffering from marked obstruction of unknown origin.

DR. WILLY MEYER said that the only cases in which he dissected the gall-bladder, beginning at the cystic duct, were those in which he had wished to test the technical benefit of such a procedure.

He considered it very interesting that careful suture of the posterior half will be sufficient to make the common duct close again after division, except there be such tension that this is impossible; in such a contingency he also would favor the plan that the omentum be turned up against the defect in the duct and thus prevent leakage.

DR. FRANZ TOREK stated that he did not believe it possible to lay down any cast-iron rule for the removal of the gall-bladder, calling attention to those cases in which the cystic duct is very easily accessible, in which instances the tendency would naturally be to take hold of the cystic duct and work from there toward the fundus. For years he has followed the method of taking hold of the cystic duct, getting his finger underneath, and then by blunt dissection with the finger work up to the fundus; by this method he can more easily find the line of cleavage, and he believed there was less hemorrhage from the liver than when removal was in the opposite direction.

DR. HERMANN FISCHER laid stress on the importance in cholecystectomy of careful dissection of the ducts, and cited a recent case showing the importance of this procedure. The patient was a very stout woman suffering from cholelithiasis, and it was found that the hepatic artery ran directly across in front of the cystic duct and might easily have been severed, as the ampulla of the gall-bladder was greatly distended with stones, if he had not adhered to his usual custom of careful dissection of the ducts.

DR. WILLIAM A. DOWNES, in closing, stated that he always made a straight abdominal incision in gall-bladder cases; he has followed the method of removing the gall-bladder from within out in the last sixty or more cases under his care. He considers this much easier in the average case,



## SARCOMA OF THE ETHMOID

because the bleeding is less. By careful splitting of the peritoneal fold and fat the duct can be caught with a sponge-holder and drawn taut, thus exposing the junction with the common duct very quickly and easily. The cystic duct can then be isolated from the vessels, and a clamp placed on the latter. The two layers of peritoneum easily unfold and there is no difficulty in separating it from the bed of the liver. In the case reported he followed this same procedure, but when the common duct which was filled with small stones was pulled forward it resembled the ampulla of the gall-bladder, and, carelessly, not stopping to separate the fold, it was cut through. He considers the method from within out the nicer operative procedure, but he is not prepared to state whether or not it is the safest method of removal.

## SARCOMA OF THE ETHMOID

DR. A. V. MOSCHCOWITZ presented the following two cases, saying that within a period of six months, through the courtesy of colleagues upon the Ophthalmological division of the hospital, there had been referred to him for operation three cases of the rather rare malady of sarcoma of the ethmoid. One of the cases was discharged from the hospital after numerous operations, with metastases in the brain, and is presumably dead. The two cases now presented are of more than passing interest, for the following reasons: First, on account of the rarity of these cases; second, because of the nature of the operation which was undertaken, particularly in Case I; third, because of the splendid cosmetic result obtained in Case I; and, finally, for the reason that both cases promise to be permanently cured.

CASE I.—Rose K., seventeen years of age, was admitted to the ophthalmologic division of the hospital July 24, 1916. Her sole complaint at that time was an exophthalmos of the left eye, which was first noticed eight months before, and which had gradually increased. Examination by Dr. Julius Wolff, Associate Ophthalmologist of the hospital, showed that the left eye protruded in an anteroposterior direction; there was slight limitation of motion on external and internal rotation. There was present a diplopia, on looking to the left, which was due solely to mechanical limitation. No bruit was heard, and nothing abnormal was felt at the orbital margin; there was present, however, a marked resistance to backward pressure of the eyeball. After removing the anterior projecting portion of the middle turbinate with a snare, Dr. Yankauer was able to expose the tumor mass and obtained several specimens for pathological examination, and thus the diagnosis of an "osteosarcoma" was established.

Patient left the hospital temporarily, and was readmitted September 30, 1916. During this interval there was no increase in the symptoms or physical signs.

*Operation* (October 4th, by Dr. Moschcowitz).—An incision was made commencing in the middle of the left eyebrow, and curving at first inward and then downward over the centre of the nose to within a half of an inch from the tip. A quadrilateral flap involving the left

nasal bone and nasal process of the superior maxilla was now sawn out, and attached only by a hinge of periosteum along its external margin. The anterior wall of the frontal sinus was removed from the mesial half. The eye being now held out of the way by retracting it in an outward and downward direction, exposed the mesial and posterior aspect of the orbit. A tumor of bony hardness, situated behind the eyeball, was exposed; it was of the size of a hazel-nut, and was attached to the os planum of the ethmoid. It was excised *in toto* by means of a chisel. The remainder of the ethmoid cells of the left side, in fact, the entire inner wall of the orbit, was also excised. In doing this step of the operation the dura mater was torn over a small area at the inner angle of the frontal sinus. The wound was packed with iodoform gauze, which was led out through the nostril. The osteo-periosteal nasal flap was now replaced and sutured into position with periosteal sutures. The skin was closed with a subcuticular stitch. Perfect primary union followed and patient was discharged nine days after operation. The exophthalmos disappeared very rapidly. The interior of the nose required long after-treatment, owing to a tendency to form granulations.

The patient is presented now, about sixteen months after operation. The only symptom remaining is that of a diplopia of a moderate degree. It is too early to speak of a radical cure, but even at this stage the case may be said to be encouraging.

CASE II.—Sam S., seven years of age, was referred February 14, 1917, by Dr. May. His illness began seven months ago, and it is definitely stated by the mother that he was struck over the right eye, after which trauma the upper lid began to droop. Subsequently the child was treated at the New York Eye and Ear Infirmary, where a diagnosis of an orbital tumor was made, and where two operations for its removal, in October and December, 1916, respectively, were undertaken. After the last operation the eye began to protrude. He also received radium and X-ray treatment. The patient complains of headache and great pain in the eye, which is totally blind since one week. Examination by Dr. Cohn, Adjunct Ophthalmologist of the hospital, showed the following: (1) A high degree of exophthalmos, so that the eye was practically lying upon the cheek; (2) keratitis with lagophthalmos; (3) hypopium, and (4) marked venous congestion of the eyelids. The Röntgen examination was not very satisfactory, as it showed even more destruction of the orbital bones than was found at the operation.

A diagnosis of retro-orbital sarcoma was made and following operation was carried out for its removal, February 16, 1917. A short transverse incision was made at the inner and outer commissure of the eye. Both lids were then dissected free and their conjunctivæ extirpated. The periosteum all around the orbital margin was now incised and elevated from the entire orbit, so that when divided in the depth of the orbit with the scissors, the entire contents could be removed *en masse*. The inner wall of the orbit, *i.e.*, that part formed by the ethmoid, was involved in the new-growth, and was also extir-

## SARCOMA OF THE ETHMOID

pated, thus opening into the nasal cavity. The skin of the eyelids was turned into the orbit, and held there by pressure. The specimen removed showed it to be composed of the eye and optic nerve, surrounded by orbital fat, and also a large vascular neoplasm, arising by a very broad base from the periosteum covering the ethmoid bone. Microscopic diagnosis, "round-celled sarcoma."

The skin flaps healed on to the denuded orbital bones practically by primary union. Patient left the hospital March 28, 1917. The boy is now, almost a year after operation, in splendid condition. There is thus far not the slightest trace of recurrence.

DR. NATHAN W. GREEN referred to the case of a little boy seen by him a year ago, referred by Dr. W. W. Gilfillan. This child had a sarcoma arising from the horizontal plate in the frontal bone on the right side, the eye was out on the cheek and appeared as big as a billiard ball on account of the chemosis. The pain was so severe that he operated for its relief and he removed all the visible growth, but he left the eye. He went back as far as the circle of Zinn and made the enucleation of the tumor apparently complete. A few months later an identical condition started in the other orbit; this was left alone for a while, as there seemed little hope of benefiting the child, but as the tumor grew it finally pushed the second eye out of position and the pain was so severe that enucleation of this tumor seemed indicated. This was done, as in the first instance, by means of a modified Krönlein's incision. There was an interval of two or three months, then a recurrence in the first eye. Deep X-ray treatment was instituted by Dr. Archibald Evans and the tumor decreased in size a little, but a profound toxæmia from absorption supervened and the little patient died. On microscopical section the tumor was found to be small round-celled sarcoma. On cross-section of the gross specimen the tumor presents a greenish appearance.

DR. WILLY MEYER cited in detail the case of a woman with epithelioma of the nose who neglected her condition until it gradually involved the adjoining tissues. A radical operation was done, removing the entire nose, both eyelids, the eyeball and the greater part of the cheek. Then immediately a large flap was taken from the forehead with the pedicle on the opposite side of the nasal bone, and the entire defect closed, grafting the forehead area, and the result was very satisfactory. At that time Dr. Warbasse, of Brooklyn, worked along these lines of cosmetic repair with papier maché. His interest was solicited for this patient and he constructed a pair of spectacles; to these he attached an artificial nose made of this material and an artificial eye. When this patient was shown to the members of the Surgical Society they were surprised to find her fairly normal appearance due to this ingenious prosthesis.

Dr. Meyer considered it of importance to immediately close the orbit by a skin flap wherever the eyelids have to be removed.

He also called attention to the remarkable results of X-ray treatment

in some of these cases. Lately he had seen Dr. Pfahler, of Philadelphia, show the photograph of a child with sarcoma of the orbit before and after treatment; before, the eyeball was protruding on the cheek; and after treatment the eyeball was shown to have entirely receded into the orbit and the child had satisfactory vision.

#### ACUTE GANGRENOUS PERFORATED DIVERTICULITIS OF THE CÆCUM

DR. ALEXIS V. MOSCHCOWITZ presented a man, forty-four years of age, who was admitted to hospital November 30, 1917. He had never been ill before, beyond an occasional momentary twinge of pain in the right iliac fossa, and which was so trifling that he did not even mention it prior to the operation. His illness began five days before with dull cramp-like pains in the right lower quadrant of the abdomen; there were absolutely no other symptoms. On examination there was found a mass the size of an egg in the right iliac fossa, which was tender on pressure; the lower part of the right rectus showed only a moderate degree of rigidity. At the operation the appendix was found to be perfectly normal. The mass palpated prior to the operation was proven to be a conglomerate mass of epiploic appendages, developed rather more than is normally seen upon the cæcum. One of these epiploic appendages was larger even than the rest, very firm, highly injected, and very brittle. It was entered with great care, and the first object that was encountered was a coprolith, about the size of a bean, lying free in a small abscess cavity; beneath it was a gangrenous area discharging pus and feculent matter. A probe led, at a depth of a little over one inch, into the cæcum. The epiploic appendage was cut off even with the cæcum, and proved to be a false diverticulum, over one inch in length. The hole in the cæcum was sutured in several layers, and was covered with omentum. Drainage with tube and rubber dam. The postoperative course was marred by a pneumonia. The healing of the wound, however, was entirely uneventful, and patient was discharged well in nineteen days.

#### RECTUS TRANSPOSITION IN HERNIA

DR. WINFIELD S. SCHLEY read a paper with the above title, for which see page 465, in April number.

DR. L. W. HOTCHKISS stated that he had never been able to persuade himself that the sutured rectus muscle would stay very long against Poupart's ligament. For a good many years after the procedure was proposed by Bloodgood he followed it, but since then had used the method of splitting the anterior sheath of the rectus muscle, using the sheath alone, attaching its edge to Poupart's ligament; he believes more strength is gained by the use of the aponeurosis of the muscle than of the muscle itself, and he sometimes uses in direct inguinal hernia the method proposed by Dr. Downes of including in the grasp of the suture through the aponeurosis the edge of the rectus muscle. He found that the rectus muscle generally pulled out but the aponeurosis did not pull out.

DR. ALEXIS V. MOSCHCOWITZ stated that he did not use the method proposed, as he believed it had its percentage of recurrences as well as others. He did not use the method because he believed it to be an unhealthy union between the rectus and Poupart's ligament; before very long the rectus separates, going back to its normal place. He advocated the Andrews method, which he described in detail. He believed the most important thing is the suture of the aponeurosis of the external oblique to Poupart's ligament, because he has convinced himself at secondary operations that even if the external oblique alone is attached to Poupart's ligament the cure in many cases is permanent. He cited a recent case in which he followed this method in a man of seventy-five years with a strangulated hernia; there was no muscle at all, only a good deal of fat, and so he was compelled to rely entirely upon the aponeurosis of the external oblique muscle.

DR. WILLY MEYER said that it seemed to him the strength of Dr. Moschcowitz's suture of the internal portion of the external oblique to Poupart's ligament lay in the fact that he put over it the lower portion of the external portion of the external oblique. He cited a case of recurring hernia in a female in which he succeeded in getting a good repair, by means of this overlapping tissue-flap suture, the patient afterward becoming pregnant, and up to date has developed no further signs of a recurrence.

DR. SEWARD ERDMAN stated that in a paper recently read before the Surgical Society he had reviewed the results in a series of herniotomies performed on the Second Surgical Division of the New York Hospital. The recurrences after all varieties of operation for direct hernia were between 15 and 20 per cent., up to date. Recurrences of direct hernia after rectus transposition were also between 15 and 20 per cent., thus revealing no especial advantage for this procedure. Statistics of recurrences after transposition of the rectus in oblique hernia are of little value, because in oblique hernia such transposition is practically never indicated; therefore it cannot be claimed that the results are influenced by such transposition.

DR. FRANZ TOREK called attention to the fact that the internal oblique and the transversalis sometimes will be inserted low down near the lower end of the rectus fascia, at other times much higher. Where they do not go well down, the rectus must be depended on for the closure of the lowest part of the hernial opening. He brings the rectus with its fascia over to Poupart's ligament without splitting the fascia, which requires a good deal of tension sometimes. Two points are that the suture must be carried way down to the lowest portion, down to the very insertion of Poupart's ligament, so close that in the last suture the needle will almost scrape the pubis as it goes through Poupart's ligament, otherwise there will be a possibility of a direct hernia. The next point is to use sutures that are dependable where there is much tension; he uses silver wire, in such instances, for the lowest suture, sometimes for the lowest two sutures. Dr. Torek stated that since his report of his series of cases operated according to his own method, as published in 1912, he had found no recurrences up to date.

DR. WILLIAM A. DOWNES stated that there were many more recurrences in hernia cases than was generally supposed. In replying to a letter from the Surgeon-General's office as to further information on the status of hernia in the enlisted men, Dr. Downes made a statement that he believed direct hernia will show from 15 to 20 per cent. of recurrences if followed long enough. This is based on his own experience. He looked up 480 cases done in four years at St. Luke's Hospital, of which 35 or 40 per cent. responded; of these there were 12 or 15 recurrences in the direct cases and these statistics are based on personal examinations of the patient. Any statistics based on written reports are unreliable; two patients wrote that they were perfectly well but on routine examination were found to have recurrences. In the majority of cases sufficient removal of the hernial sac is not done. As far as the use of the rectus muscle is concerned he suggests a compromise, using both the aponeurosis and the muscle.

DR. W. S. SCHLEY emphasized the necessity of relief of tension in utilizing the rectus muscle, and suggested the wide opening of the sheath of the muscle and the introduction of at least four sutures, then insisting upon the patient remaining in bed for eighteen days, thus saving a month in convalescence and giving a good primary union. If the patient is allowed up earlier so that the sutures are not absorbed and act as a foreign body, good results cannot be expected. If the operation as he recommends is done, he believes the rectus transposition gives the best result so far obtained. In all cases so far followed by him there have been no recurrences.

#### PREVENTION OF PERMANENT BRONCHIAL FISTULÆ

DR. HOWARD LILIENTHAL presented a paper with the above title, for which see page 538.

DR. MARTIN W. WARE (by invitation) stated that he had often witnessed the operations of Dr. Lilienthal, and he could substantiate his statement, that in all these cases the fistula in the bronchus was far from the surface with an intervening cavity where granulation could occur. An important point is that all of these cases were not amenable to the methods advocated where the tissue is pliable; here the tissue was rotten and the mass ligature was applied in a great many instances. He called attention to the channel drainage which may bring about a more direct connection between the bronchus and the surface of the body, and thus favor fistula formation, since the mucous membrane and skin readily bridge over and line the tract with epithelium. A like condition prevails in all intestinal fistula leading very directly to hollow viscera, whereas when the tract is indirect or tortuous and of great length any intervening area of granulation by its larger amount may by its growth obviate fistula formation. The tube drainage in these cases by a buttonhole far removed from the line of incision tends to create long intermediate areas of granulation tissue between the bronchus and the skin favorable to closure.

## HYPOGLOSSAL-FACIAL ANASTOMOSIS FOR FACIAL PARALYSIS

DR. HERMANN FISCHER presented screen pictures of a man who, on September 20, 1915, thoughtlessly expressed the contents of a pimple on right side of neck below angle of jaw. A few days later evidence of infection appeared and seemingly matured as a small carbuncle. This was widely incised under anæsthesia on September 29th. Practically no pus or other product of disintegration was obtained. A few days later two small masses resembling carbuncular core were discharged.

The swelling persisted, gradually extending up and about the ear until October 19th, one month after operation, when a total facial paralysis of the right side supervened, which, from the parts involved, was evidently of the infranuclear type. From this time the local condition took on a severely malignant type, rapidly extending over the side of the head from the jaw back to the median line of the neck posteriorly and from the shoulder to the zygomatic line, almost submerging the pinna. The skin assumed a dusky red similar to that of malignant erysipelas. This swelling was accompanied by excruciating pain which radiated over the side of head and neck, not being localized. The neck was immobilized by it and felt as if in a splint. Later the swollen tissues became somewhat doughy and pitted on pressure in the region below and in front of the ear. During this time deafness of the right ear developed and advanced to completeness. Classic symptoms of mastoiditis were absent and an exploratory paracentesis tympani failed to discover more than a congested condition of the middle ear, yielding but a few drops of bloody serum. There was profound systemic infection, severe arthritis of the left shoulder and recurrences of severe myalgia in various parts of the body.

Coincident with this rapid extension of the local trouble, the swelling at the site of the infection subsided. The patient experienced a constant sense of pressure deep in front of the mastoid process as though a wedge had been forced deeply internal and anterior to that structure. Later it was thought that deep fluctuation was detected over this area just posterior to the ramus of the jaw. An exploratory incision was made without illuminating the situation. This incision failed to heal, however, and resulted in a small slightly discharging sinus. Conditions gradually improved so that the patient was about the house by November 25th. He still sustained a pronounced deafness, the "wedge-like" sensation persisted and there was no abatement of the paralysis. On December 9th a few drops of pus were found in the external auditory canal of the affected side. The ear was examined by Dr. Case, of Elmira, N. Y., and a small polyp was found arising from the floor of the canal, just exterior to the membrana tympani. When this was snared out, a small opening was found. This opening led into a channel following the line of the facial canal, in which the probe detected necrosed bone. This channel was found to be continuous with that of the sinus before mentioned.

On the following day the mastoid was opened and from a large necrotic cavity were removed a number of loose sequestra. Attached to the whole length of the largest of these, three-eighths inch in length, was a macerated section of the facial nerve with frayed ends.

The operation revealed the most unusual condition of a virulently septic process, ascending through the stylomastoid foramen, causing extensive necrosis of the bone, surrounding the facial nerve and finally destruction of the nerve itself. Paralysis occurred in the fourth week. The operation was done when the total paralysis had lasted for eight weeks. For the relief of this paralysis an hypoglossal-facial nerve anastomosis was done August 29, 1916.

Technic: Skin incision two fingers' breadth below ramus of mandible from lowest point of mastoid process to midline below chin. The line of incision corresponds to the course of the digastric muscle. The skin flap is dissected up from the underlying tissues until the lower part of the cheek with parotis is laid bare. The hypoglossal nerve is dissected out and cut off where it disappears under the mylohyoid muscle. Now the trunk of the facial muscle is looked for below and behind the parotid gland at the point where it leaves the stylomastoid foramen. To accomplish this, the parotid gland must be carefully raised from its bed, without interfering with the numerous branches in which the facial nerve splits up. There was quite some difficulty in finding the nerve on account of the dense and hard scar tissue which was caused by the previous operations. After the nerve was laid bare just below the external auditory meatus, it was followed up to the point where it emerges from the stylomastoid foramen. It was cut across close to the foramen and its peripheral end was sutured to the central stump of the hypoglossal nerve. In handling the nerves, extreme caution was exercised to grasp the perineurium only by means of small mouse-toothed forceps. Three sutures of finest silk, catching the perineurium of the nerves, were used to perfect the anastomosis. The parotid gland was replaced over the nerve and the wound closed. There was quite some annoying hemorrhage from the bulbus of the jugular vein, which had been nicked inadvertently while dissecting the scar-tissue. It was finally controlled by suture of the vein.

The wound healed by primary union and the patient left the hospital on the sixth day after the operation. Following the operation there was much induration of the tissues over the ramus of the jaw and along the line of incision which persisted for some months. There was also numbness and tingling sensation, intense upon touch throughout the indurated area and the pinna. The patient experienced great difficulty in swallowing for several weeks after the operation. At first this trouble was extremely annoying, accomplished with great difficulty and attended by choking with almost every attempt, no matter what the nature of the food. Soon it was found that if a bolus not too large or too small was formed it could be grasped by the muscles—a larger being refused and the small not affording



## TRANSPLANT ON HAND AFTER CARCINOMA

sufficient bulk. It also required some time to educate the tongue to deliver masticated food to the proper points for swallowing. Both conditions were helped by the generous use of fluid "to wash" food down. Speech has not been materially disturbed.

The patient is conscious of a little more difficulty in forming words containing the linguals, but on the whole, this phase of the postoperative results is not worthy of a place in the factors to be considered.

DR. A. S. TAYLOR considered the result in this case was most surprisingly good. Most of the men who have written on this subject say that one should completely divide the hypoglossal transversely to get end-to-end suture with the facial. In a series of 15 or 16 cases published in 1905, in every case Dr. Taylor used simply the lateral implantation of the facial into a longitudinal split in the hypoglossal. The advantage in this method is that while there is a temporary disturbance of the hypoglossal function, after a couple of months there is complete return of function to the hypoglossal with a satisfactory return in the facial. If one takes these cases when they first begin to show return of power in the facial nerve, and prescribes motions and exercises involving hyperactivity in the muscles controlled by the hypoglossal, one can increase the rapidity of return of power in the facial muscles, because, by overstimulating, nervous energy will overflow from the hypoglossal into the facial with return of power in that area.

*Stated Meeting, Held February 13, 1918*

The Vice-President, DR. WILLIAM A. DOWNES, in the Chair

## TRANSPLANT ON HAND AFTER OPERATION FOR CARCINOMA

DR. EDWARD M. FOOTE presented a man aged thirty-one. When eighteen years of age, a "wart" appeared in the web between the index and middle fingers of the left hand. In the following twelve years he had many salves applied; treatments by electricity; more than twenty-four X-ray treatments, and several minor operations, including one excision and skin-grafting. Sometimes the ulcer healed, but always reappeared in a few months or less.

February 5, 1917: Doctor Foote excised the tumor freely, carrying the dissection well down between the fingers to the muscles, and stitched into the wound a flap from the abdomen. The pedicle was partly divided on the third day, and completely divided on the eleventh day. Healing was uneventful. Four months later, when atrophy was complete, some excess fat was removed from beneath the transplant. Doctor Jessup, who examined the tumor, reported it to be a prickle-cell epithelioma.

At the present time there is no sign of recurrence. The skin of the transplant has gradually assumed somewhat the appearance of the surrounding skin. Tactile sensation has appeared in a part of the transplant, and the

sense of pain on pinching or on pulling the fine hairs is more widely distributed over the transplanted area.

## LUNG ABSCESS

DR. NATHAN W. GREEN presented a man, thirty-two years of age, who was admitted to the City Hospital to the service of Dr. E. P. Shelby, December 4, 1917. The diagnosis on admission was bronchitis. At that time he was suffering from cough and a profuse expectoration with a fetid odor and a pain in his right chest. On January 2, 1918, two ribs were partially resected subperiosteally. The pleura was found thickened and a needle introduced through this thickened pleura withdrew air. An opening was made along by this needle and a cavity encountered one inch anterior to the pleura. This cavity would contain about an ounce of fluid. It contained foul-smelling pus. A large rubber tube was introduced into it and drainage established posteriorly. The temperature was normal on the second day after the operation and the tube was left in place two weeks, then removed a few days, and again inserted for six days more, when it was removed altogether. The quantity of expectoration rapidly diminished, and except for an afternoon temperature coming on two weeks after operation and lasting several days, he had an uninterrupted convalescence. The fetid odor from the breath has now cleared up and there is practically no expectoration (February 13, 1918).

DR. WILLY MEYER called attention to the statement that Doctor Green withdrew air with the syringe in his aspiration, and in this connection he detailed the case of a patient under his own observation who had been coughing pus for quite a long time, where he could find with the needle no pus in the chest, but where on aspiration he withdrew air. He considers the withdrawal of air from the lung as an important symptom of having entered a cavity, provided a reliable record-syringe is used.

He considered the question of whether to aspirate before operation, and suggested where possible having a bronchoscopic examination made for the detection of the exact location of the pus. He personally feels more and more inclined to advocate preoperative aspiration for preoperative diagnostic purposes. He referred to a recent case in which he attempted to localize the abscess, besides the usual clinical methods, by bronchoscopy and the X-rays, and in which case he believes had he inserted the needle he would have been led to enter the cavity from the back of the patient rather than from the front and thus had a much easier operation. Another question he brought forward was the method of incising the lung, with the knife or with the cautery. He always uses the Paquelin cautery if deeper portions of the lung have to be entered.

DR. ROBERT T. MORRIS stated that it was of interest to decide what to do upon opening and finding the pleura not involved. He had seen Schede open the chest for empyema in a case in which the pleura was found to be perfectly normal but where the diaphragm was bulging—a case of subdiaphragmatic

## ABSCESS OF LIVER DISCHARGING THROUGH BRONCHI

abscess; he closed the chest wound, and then entered the abdomen below the diaphragm. He referred to a recent case under his observation in which the X-rays showed the diaphragm to be highly arched but which later turned out to be a liver abscess. The question of lung abscess had been entertained until the radiograph disclosed the real situation.

DR. N. W. GREEN, in closing, stated that in the case reported the lung was adherent to the parietal pleura and the puncture was made through this so there was no free chest cavity to contaminate. The puncture was done at the time of operation. He stated that he sometimes used the knife, then scissors, first closed when introduced, then opened, and he never feared bleeding to any extent because the puncture is made at the periphery of the lung where the vessels are small, and any bleeding which might occur he believed could be controlled by packing.

## ABSCESS OF LIVER DISCHARGING THROUGH BRONCHI

DR. N. W. GREEN presented a case of a man who was admitted to the surgical service of the City Hospital, October 5, 1917, complaining of weakness, anorexia and loss of weight. A diagnosis of empyema was made and on October 9, 1917, he was operated on for this condition, resecting the eighth rib. He did not improve rapidly, but rather continued to fail. Upon rounds it was observed that he was expectorating a yellow sputum which appeared strongly bile stained. There was no characteristic odor to it. After studying the case for some time, the diagnosis of a fistulous tract connected with the liver was made by Doctor Green. In other words, that a liver abscess was now being discharged through the trachea. This was confirmed by Dr. E. P. Shelby, attending physician. An operation was performed on November 24, 1917, by Doctor Green, resecting part of the ninth rib and opening the old empyema cavity. The examining finger detected the outline of this cavity together with a smaller cavity at the apex of the empyema cavity, which in turn communicated with a bronchus. In the other direction a small opening about the size of a slate pencil was detected on the dome of the diaphragm, which led through the diaphragm. An artery clamp was introduced closed through this hole and the opening was stretched to finally admit the finger. The finger then detected a large cavity the size of a small orange underneath the diaphragm and within the substance of the liver. The opening was now made larger by cutting it directly outward through the diaphragm with a knife and two sets of large double drainage tubes introduced—one set into the liver cavity and one into the combined lung abscess-empyema cavity. The discharge through these tubes was at first profuse. The discharge through his trachea rapidly diminished. After a few weeks both sets of tubes were removed and the discharge through the external sinus has now ceased. The expectoration has ceased and the patient has gained about twenty pounds. An interesting point in his case is the fact that, owing to the presence of bile, the fetid odor which is so frequent with lung abscesses was absent.

## DEPRESSED FRACTURE OF SKULL OVER SPEECH CENTRE

DR. N. W. GREEN presented a man, aged twenty-five years, who was admitted to the Surgical Service of the City Hospital, January 1, 1918, with a story that he had been celebrating the New Year's Eve, the night before, with some friends. Upon admission he presented the following conditions: He showed a lacerated wound of the scalp where he had been struck by some blunt object. There was ecchymosis of the left eye and epistaxis. The right side of his face was paralyzed. He was unable to speak, although he seemed to understand what we said to him and he could smile and make vocal noises. Upon examination a depression in the skull was made out at the anterior and lower end of the scalp wound which was over the left temple. This depression was about an inch and a half long and half an inch wide.

An operation to relieve the depression was performed at once under general anæsthesia and a depressed portion of bone one and a half inches long and one-half to three-quarters of an inch wide was removed. The dura was opened and blood clots together with lacerated brain were extruded. The dura was again closed and the scalp wound closed completely, except for a small drain. One week after the operation the patient was again talking, but in a hesitating manner. His speech has continued to improve to the present time.

## MORPHŒA OR SCLERODERMA

DR. WILLIAM B. COLEY said that while the etiology of morphœa is extremely obscure, there is some evidence to show that it has some relation to changes in the thyroid gland. Robinson, in a "Report of a Case of Scleroderma of the Skin" (*American Journal of the Medical Sciences*, November, 1917, page 657), states that the average occurrence of idiopathic, atrophic dermatitides taken from five large skin clinics in this country and abroad is 1 in every 2580 cases and he believes that every case should be reported in order to add to the general knowledge of a rare condition. It was first described by Thirlial in 1845, under the name of "ichthyosis," and later in 1854 by Addison. Erasmus Wilson termed it morphœa, when the condition is that of a circumscribed scleroderma. Osler, who perhaps has given the best description of the condition, defines it as "a nutritional disturbance of the skin, patchy or diffuse, leading to induration and atrophy; usually considered to be a trophoneurosis, the characteristic lesions being areas of skin which are waxy and œdematous-looking, surrounded by a violaceous areola, and which gradually become brown, tense, hard, and hide-bound, with increase in collagenous material."

In 68 cases analyzed by Robinson, in 60 or 88 per cent. the hands were affected; 19 per cent. showed changes in the thyroid. Because it was believed that this condition was due to a thyroid deficiency, thyroid extract was given, resulting in improvement in 2 cases, no improvement in 4, and no change noted in 5 cases.

In Robinson's series, the thyroid was found unchanged in 12 cases, atrophic in 3, and hypertrophic in 2. Syphilis was negative in 13 cases and positive in 9; Raynaud's disease was present in 4 cases, Addison's disease in 1, tuberculosis in 2, and diabetes in 2. Robinson states that it has quite generally been accepted that scleroderma is a trophoneurosis and due probably to a disturbance of the thyroid function. He adds, "The thyroid is not the only gland of internal secretion that is affected. Roux found sclerotic changes in the hypophysis, and believed it to be a functional disturbance of that gland. Changes in the adrenals have been described. Dupre, Kahn, Rosch and others believed in a pluriglandular pathogenesis. Falta and Caspary believe that in scleroderma the glands of internal secretion are affected, but the process is not primary in the ductless glandular system. Since all the glands of internal secretion may be affected in those having scleroderma, and since they are all probably influenced by the vegetative nervous system, it is possible that a disturbance of this nervous system may be the primary cause, though this has certainly not been proven. Osler, Grasset, and Dehu, from the changes in the nervous system, the perversion of nutrition, analogous to that of myxedema, together with Jeanselme, Singer, Hektoen, Leredde, Thomas and others, regarded the cause as that of a thyroid deficiency."

Doctor Coley presented a man, aged eighteen years. Family history negative. Present trouble began eight years ago in the nature of a callous formation on the hands, which areas became very tender. Two to three weeks later the same condition appeared over the soles of the feet, and in the course of several months the latter also became tender. During the early stages of the disease the patient would have periods of remission when the trouble almost completely disappeared, but these intervals later became shorter and shorter until during the last few years the progress of the disease had been almost continuous and the patient became practically a complete invalid. He was referred to Doctor Coley by Dr. Henry McMahon Painter in November, 1917. A letter from Dr. Jos. A. Dillon, of New York, who had had the case more or less under his supervision, states:

On February 17, 1909, the patient came under treatment for callositis of the feet and tips of fingers. The usual course of events has been that the hard epidermis would come away and leave the underlying parts in good condition. He would at first be free from the trouble for many months, but there was inevitably a recurrence and the intervals between attacks shorter until it has been almost continuous. The lesions have increased considerably in size. Wassermann test negative.

All kinds of drug treatment have been used; arsenic, mercury, iron, iodides internally, and externally green soap, mercurial ointments, salicylic collodion, formaldehyde—all without pronounced effect. He was sent to the Skin and Cancer Hospital in 1915 in the hope that Röntgen ray or radium treatment would be tried, but as he seemed to do well on salicylic ointment he was discharged after two weeks' treatment. He has been shown to physicians at Society meetings, but no one has made a suggestion that was helpful. He has not been at the Neurological Institute.

*The blood examination*, made November 3, 1917, soon after his admission to the Memorial Hospital, showed: Red blood-cells, 4,400,000; hæmoglobin, 87; lymphocytes, 32 per cent.; white blood-cells, 14,400; polymorphonuclears, 67 per cent.; eosinophiles, 1 per cent.

At the time of his entrance on October 26, 1917, the palmar surface of both his hands and feet were completely covered with enormously thickened patches of callus-like tissue which somewhat resembled keloid. The fingers and toes were markedly flexed and it was impossible for him to extend them; the patient was unable to walk or to use his hands in any way. The hands and feet were so sensitive that the slightest touch caused severe pain.

*Pathological Report* (November 1, 1917).—Hyperkeratosis. Tumor-like hyperplasia of intermediate hornifying epithelium. Hypertrophy and elongation of rete pegs. Plasma cell infiltration of cutis.

*X-ray Findings* (November 3, 1917).—Bones of hands show marked osteoporosis throughout.

After looking up the literature on the subject, Doctor Coley decided to try the suggestion of Dr. A. S. Robinson, of Cleveland, and put the patient upon the thyroid gland extract, 6 grains 3 times a day. The following results can best be noted by an inspection of Figs. 1-6.

In Fig. 1, taken November 16, 1917, the areas of cornification show a marked tendency to break up into separate island or patches with fissures and cracks between. In many places the horny layers of tissue are beginning to peel off. The power of extending fingers is much greater than when he entered the hospital.

Fig. 2, taken December 1, 1917, shows the condition of the hands to have cleared up remarkably, only one large patch remaining on one hand; extension almost complete.

Fig. 3, taken December 22, 1917, shows the condition of the hands almost normal. While the patient has had periods of remission during the last eight years, as has been stated, during the last year the progress of the disease has been almost continuous, and at no period during the whole eight years has there been such complete disappearance of the lesions as at present; therefore, it would seem probable that the treatment with the thyroid gland extract has been largely responsible for the improvement in the condition.

*Pathological Report No. 2* (January 19, 1918).—Report on microscopical examination of case of D., by Dr. Ewing:

In the material received the thickness of the Malpighian layer is between 30 and 50 millimetres, to which an exaggeration of all the strata contributes, while the derma is also thickened and cellular.

In the derma there is a uniform infiltration by round-cells, mostly lymphocytes, while the capillaries are very numerous and much congested. The sweat-glands are normal, and no hair follicles are present.

The papillæ of the epidermal layer are very much elongated and project as narrow cords deeply into the derma. In the basal layer of cells there are numerous mitoses.

At the edges of the lesion the Malpighian layer ends in a broad zona granulosa, which is immediately succeeded by a very thick deposit of nearly homogeneous keratin layer, but in the main portions of the lesion the process of keratosis is interrupted by a broad layer of rather small eosin staining cells which are so abundant as to suggest an approach to a tumor process. These eosin staining cells contain relatively large and sometimes multiple nuclei; the

FIG. 1.



FIG. 2.



FIG. 3.



FIG. 1.—Before treatment.  
FIG. 2.—After one month's treatment.  
FIG. 3.—After two months' treatment.



FIG. 4.—Microscopic section (low power).



FIG. 5.—Microscopic section (low power).



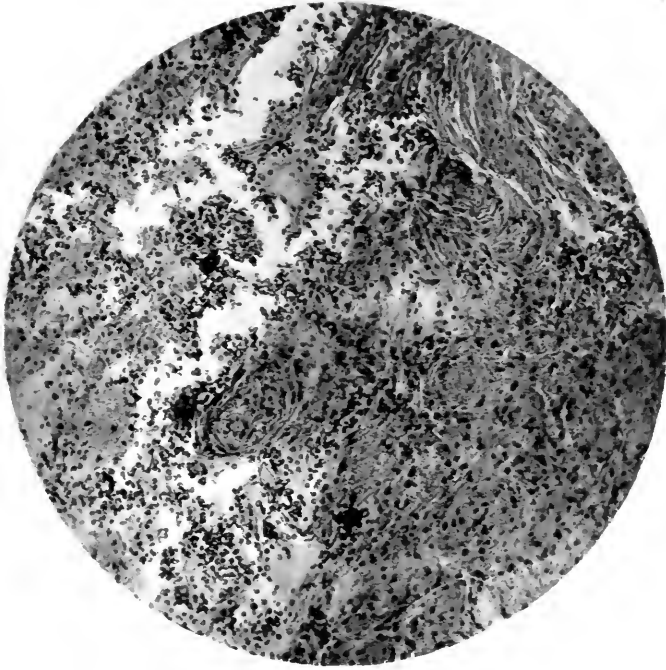


FIG. 6.—Microscopic section (high power).



FIG. 7.—Case of extensive scleroderma in the later stages.

## MORPHŒA OR SCLERODERMA

cells bodies are partly homogeneous and keratinized, and many cells show hydropic vacuoles. In the outer half of this peculiar layer there is hemorrhage, and the cells are looser, many of them forming indistinct small pearls.

The outer layers of the lesion are composed of a thick mass of keratinized material, which is dense, structureless, lamellated, acid and basic staining in different points, and sometimes broken by pockets of semifluid material.

The main histological feature of the process is an excessive and abnormal keratinization, marked by a remarkable excess of partly keratinized cells which form a thick layer beyond the *zona granulosa*.

The process may be interpreted as a nutritional disorder, affecting the function of keratin formation. The only mitotic cell proliferation is found in the basal layer of the papillæ.

(Signed) J. EWING.

Examination January 25, 1918, shows the condition the same as at the time of the last note; the hands are entirely normal, the patient is able to walk, and there is no evidence of any return of the trouble.

Doctor Coley believes it is only fair to state that the patient has had periods of remission and of partial disappearance of the lesions before, especially in the early stages of the disease, but the disappearance has never been so complete nor the period of freedom from trouble so prolonged as at present, and Doctor Coley thinks it probable that the thyroid extract had some part in the favorable result.

DR. ROYAL WHITMAN said that he had seen a number of cases of scleroderma, but that they were of a different type from that presented. The lesion was extensive and deep seated, the affected skin changing to an indurated substance, resembling somewhat the scar of a burn, which contracting distorted the affected part. In one case, seen recently, the disease was very extensive, involving all the extremities, causing distortion and ankylosis of the joints with large areas of ulceration.

DR. JOHN ROGERS thought it interesting to figure out how the thyroid extract affected the condition, stating there was probably not an organ in the body which had not been treated by the use of thyroid. From the experiments he had been able to follow, the only material demonstrable action in the thyroid acts through the vagus and not through the sympathetic system. He believed the condition exhibited might have some relation to a trophoneurosis, and this might explain the action of the thyroid feeding through the autonomic fibres which are known to supply at least the sweat-glands.

DR. WILLIAM B. COLEY, in closing, stated that he believed Dr. Whitman's case was a variety of the same general type of progressive scleroderma. Characteristic lesions increase with remissions in the earlier stages. Ulcerations occur in 50 per cent., according to Robinson. The supposition is that it is a trophic neurosis due to thyroid deficiency. He stated that the treatment so far had been entirely empirical; actual disturbances in the thyroid had been noted in 19 per cent. in one collection of cases, and even in larger percentage in another collection, so that now thyroid has been used in a considerable number of cases with marked improvement in some. With regard to the condition being of congenital origin it is not so far regarded

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in this light. Syphilis plays a very small part, being found negative in 18 cases and positive in 9. The etiology is acceded to be obscure.

Doctor Coley added that it is possible that the improvement in his own case was due to a natural remission of the disease rather than to a result of the thyroid treatment, although the history of the case would make this improbable.

### REPAIR OF COMPLETE RECTO-VAGINAL LACERATION

DR. IRVING S. HAYNES read a paper with the above title, for which see page 501.

### FRACTURE OF THE CERVICAL SPINE PRODUCING BROWN-SÉQUARD SYNDROME

DR. DEWITT STETTEN presented a man who was discharged from the Army because of his present condition, which was caused by his diving into a shallow tank on June 9, 1917. He struck his head, was unconscious for a few days, and was found to be paralyzed on his left side. He was regarded at first as a case of cranial injury with cerebral hemiplegia. Later examination showed in addition to the left homolateral corticospinal hemiplegia a contralateral analgesia and thermoanæsthesia of the right leg and side to above the nipple line, *i.e.*, a Brown-Séquad paralysis due to a hemi-lesion of the left side of the lower cervical cord. The radiographic examination shows a compression fracture of the fourth, fifth and sixth cervical vertebræ with backward dislocation of the bodies.

## CORRESPONDENCE

### TORSION AND STRANGULATION OF A PYOSALPINX

EDITOR ANNALS OF SURGERY:

The twisting of a pyosalpinx to a sufficient extent to cause strangulation seems to be a rare accident; and a cursory examination of the literature did not reveal a reported case. In the very full analysis of seven hundred cases made by Goth<sup>1</sup> no mention is made of the occurrence of this condition. Hence it would seem that the adhesions which usually occur in most of these cases are sufficient to prevent the peristaltic movements of the intestine and exercise from rotating them. In view of these considerations I beg to report the following case:

A girl, aged twenty years, white, was admitted to the hospital of the University of Kansas on September 19, 1917, complaining of pain throughout the abdomen with severe cramp-like pain on the right side. She states that she was perfectly well until five days previous to her admission to the hospital. At that time she began to have some pain of an aching character to the right of the umbilicus. The pain was the first of the kind that she had ever experienced; and at first it did not prevent her eating her meals regularly or continuing sewing on the machine, as was her habit. This pain continued two days; then on the third day she felt perfectly well. About midnight of the third day she awoke with a severe cramping pain in right side of abdomen. She was badly nauseated, and vomited several times. The following day she felt a little easier, but had several attacks of a severe cramping pain which was always located on the right side. At the time of admission to the hospital she felt less pain. She was a well-developed young woman who did not present an appearance of being particularly sick; pulse 76 and of good quality; temperature 99.6°. She placed her hand to the right side occasionally and preferred to lie with the legs flexed; though she did not seem to be in pain. The heart and lungs were normal. The abdomen showed some rigidity and tenderness, especially over the right lower quadrant, where an indistinct mass about the size of an egg could be palpated. She had a leukocytosis of 15,000, with 76 per cent. of polymorphonuclear leucocytes. A vaginal examination revealed a small cervix and uterus in normal position. There was some resistance on both sides, but the patient was so tender that a satisfactory pelvic examination could not be made. She was menstruating profusely and said that she also menstruated profusely three weeks ago.

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<sup>1</sup>Dr. Gayos Goth: Klinische Studie über sieben hundert Fälle von entzündlichen adnextumoren. Archiv für Gynekologie, Bd. 92.

On September 20, 1917, under ether anæsthesia, a median incision four inches long was made. A quantity of bloody serum escaped from the abdominal cavity. The mass was found to be attached to the uterus and was apparently a pyosalpinx which had been turned one and a half revolutions towards the right and completely strangulated, being black and œdematous. There were no adhesions. The mass was removed. On the left side there was a mass of similar size, with very light adhesions and not strangulated. It also was removed. There were some slight fibrin deposits on the small intestines. The appendix was looked for casually, but as the cæcum was not seen and there seemed to be no evidence of a pathological appendiceal condition, the search was not continued.

The recovery was uneventful and the incision healed by primary union. The patient was discharged on October 4, 1917.

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## ON TUMORS OF THE SALIVARY GLANDS

EDITOR ANNALS OF SURGERY:

In the ANNALS OF SURGERY for January, 1911 (lxvii, 67), there appears a paper by Drs. J. Forman and J. H. Warren on "The So-called Mixed Tumors of the Salivary Glands, with a Possible Explanation of the Morphological Behavior of the Tumor Cells." It is based on a study of seven cases, the "stroma" of three of which contain cartilage. The "parenchyma" presents the usual appearance of gland-like structures, of interlacing tubules, and of flattening of the cells, whose resemblance to endothelium is striking in places. No evidence, however, was found which showed that they are of endothelial origin. The last case closely simulates a "histoid carcinoma of the epidermoid variety." It is, in other words, a squamous-celled carcinoma.

The authors point out that, in order to explain the presence of "parenchyma" and "stroma" in these tumors, embryonic inclusions of meso- and of epiblast have been postulated by different writers on the subject. They "are of opinion that a simpler explanation of these new-growths is at hand, if one takes into consideration that the derivation of some of the head cartilages can be ascribed to epithelium." They next review some of the papers on this subject, and quite reasonably conclude that, if cartilage arises in this way in the lower vertebrates, "there is a possibility, if not a probability, that there is in the head and brachial region of the human embryo mesenchyme which has been derived from ectoderm. Later this may differentiate into cartilage," etc. "Inclusion or misplacement of this ectodermal mesenchyme gives rise to the so-called mixed tumors of the salivary glands."

I am myself a firm believer in the mixed origin of the mesenchyme, and have read Forman and Warren's paper with much appreciation. The development of the cranial and branchial regions is a highly complicated one,

and the evidence that these writers have collected from the literature is not absolutely convincing. I therefore look forward with much interest to Landacre and Warren's researches on the subject, which are shortly to appear. The reason why the evidence is not conclusive is not far to seek. The mesenchyme cells that are budded off from the epidermis are identical in structure with those derived from other sources. As the cartilage does not become recognizable as such until later, and as it is not situated immediately under the skin, it is difficult, if not impossible, to demonstrate beyond question the ultimate origin of its cells. To V. Szily<sup>6</sup> belongs the credit of having proved that parts of the skeletal system actually are formed by the epiblast. He showed that, in the tail-fin of the trout, some of the superficial bones arise within the deeper layers of the epidermis, and that they are at first completely surrounded by *epithelial* osteoblasts. The same author<sup>6</sup> has demonstrated the origin of the *sphincter pupillæ* from the epithelium of the iris. Heerfordt<sup>1</sup> had previously proved the same derivation for the *dilatator pupillæ*. These three papers, if, as a morbid anatomist, I am qualified to judge, establish beyond all manner of doubt that mesenchymal tissues can and do come from the epiblast. They greatly strengthen the corresponding work done on the cranial and branchial cartilages. I may add that there is a considerable amount of evidence that the cutis is derived from the epidermis. Retterer,<sup>4</sup> to take but one instance, believes that this takes place in man throughout life.

These researches are of fundamental importance. If correct, they upset the doctrine of the specificity of the germinal layers, a doctrine which has been believed in and taught as a first principle by all the most eminent authorities in every branch of biological science. They should therefore not be taken lightly, but be carefully weighed before being accepted. I, for one, believe that their correctness has been established by the three instances referred to above, and that we are therefore justified in using them to explain other conditions, an instance of which are the mixed tumors of the salivary glands. In this I am in perfect agreement with Forman and Warren. I must, however, deplore that they apparently did not trouble to acquire a thorough knowledge of the literature of this subject. Had they done so, the writings of Krompecher, whose name is not once mentioned in their paper, could not possibly have escaped their attention. In two papers,<sup>2, 3</sup> one of which is a continuation of the other, and which appeared ten years ago in *Ziegler's Beitræge* (which surely are read in America?) his views are, briefly, expressed thus:

Salivary tumors are basal-celled carcinomata, a group which includes rodent ulcer. They are epi- and hypoblastic according to their situation. The former only concern us here. In the case of the salivary tumors it is impossible to prove their connection with normal epithelium, but their true nature is easily demonstrable by a study of the comparative morphology of basal-celled carcinomata in general. There is no sharp line of separation between epithelium and connective tissue; the cells of the former become

stellate, acquire processes, and pass into the stroma, from whose corpuscles they cannot be distinguished. In fact, *they become connective-tissue cells*. He next describes all the pathological conditions in which he believes this transformation to occur, and goes into the zoological and embryological literature. He does not omit the development of cartilage from epiblast, but, perhaps for the same reasons that I have given, he lays no stress on it.

Krompecher thus comes to the conclusion that, in basal-celled carcinoma, including the tumors of the salivary glands, the connective tissue is budded off from the epithelium, *i.e.*, it is ectodermal mesenchyme. Forman and Warren arrive at precisely the same conclusion, but have reached it by a different way. The former argues from the appearances which can be seen in a large number of actual cases, and the latter from the analogy of the development of the cranial cartilages in the lower animals. The weakness of Krompecher's evidence, when applied to salivary tumors, lies in the impossibility of proving that they arise in the epithelium of the gland. His contention is greatly strengthened by their very close similarity to certain epidermal new-growths of the head, a fact that I can corroborate from my own experience. Forman and Warren's weakness lies in the fact that, granted that the epiblastic origin of the cranial cartilages has been satisfactorily proved for the lower vertebrates, it has not been so proved for man or is ever, as they themselves admit, likely to be. Both sets of writers can therefore claim merely to have advanced a working hypothesis based on analogy.

My excuse for writing these lines is made by the importance of the subject. Not only do these researches shake the very foundations of biologic doctrine, but, to take an instance nearer home, they upset some of the most cherished theories held by pathologists. The assumption of displaced embryonic rests in the explanation of tumors will in many cases be found to be unnecessary. These mystical beings will, I trust, become less and less common as our knowledge of the development of the mesenchyme grows.

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- <sup>3</sup> Krompecher: *Ibid.*, p. 88.
- <sup>4</sup> Retterer: *Comp. rend. d. sc. et. mém. de a soc. de biol. Paris*, 1916, lxxix, p. 1113.
- <sup>5</sup> V. Szily: *Anat. Anzeiger*, 1902, xx, p. 161.
- <sup>6</sup> V. Szily: *Anat. Hefte*, 1907, xxxiii, Abt. 1, p. 227.



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## CONGENITAL VARIATIONS IN THE PERITONEAL RELATIONS OF THE ASCENDING COLON, CÆCUM, APPENDIX AND TERMINAL ILEUM

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### I. INTRODUCTION

It is customary to consider that peritoneal adhesions result from peritoneal inflammation and represent a reaction on the part of the peritoneum to injury. Such an injury may be mechanical, as paracentesis, operative damage, etc.; chemical, as the so-called toxic inflammation in Bright's disease, etc.; parasitical, as in infection of the peritoneal cavity,<sup>1</sup> or coincidental to inflammation of contiguous viscera. The etiology is easy to ascertain in the majority of instances, and even in the more puzzling conditions, association with lesions elsewhere or a very definite anatomical picture renders the classification not difficult, as in polyserosites,<sup>3, 4</sup> chronic hemorrhagic peritonitis, and peritonitis productiva or obliterans. This is especially true of the adhesions noticed in the course of the cursory examination of the peritoneum usually employed at necropsy. If, however, one examines with care certain portions of the peritoneum and especially those portions in the neighborhood of the ascending and transverse colon, not only adhesions of very apparent inflammatory origin but also "idiopathic adhesions" and variations in the peritoneal reflections appear with such frequency that one is tempted to consider such structures as normal, or if abnormal the result of some pathological condition surprisingly prevalent.

It is our intention to discuss the origin, frequency of occurrence and significance of this particular group of adhesions, together with supposedly associated variations in the position of the colon.

### II. HISTORICAL

For an intelligent discussion of this subject, a proper historical perspective is invaluable, not only as regards the inflammatory structures, but especially in connection with the abnormalities arising during the course of the development of the intestine. The development of the intestine, the

<sup>1</sup> For a general discussion of peritonitis see von Brunn<sup>1</sup> (1885-1900). Nothnagel.<sup>2</sup>

formation of its mesentery and its relations with the surrounding organs is a subject that has been pregnant with interest for many generations. Casual references are not infrequent in the works of the older anatomists. Galen<sup>b</sup> refers to the mesentery as a "peritoneum duplex" and Morgagni describes in many cases adhesions of the peritoneum.<sup>6</sup> With the beginning of the nineteenth century this interest became accentuated. John Hunter,<sup>7</sup> in 1802, first noted in the embryo of man the close relationship of the intestine to the umbilical cœlom and this was described in detail by Meckel,<sup>8</sup> in 1817, to whom we owe the greater part of our knowledge of the diverticulum which bears his name. The work of the latter was not, however, confined to the description of this one anomaly, but included the first detailed account, founded upon careful observation, of the embryonic development of the intestine and the great omentum. Until the time of Toldt it was to remain the authoritative work upon this subject. At about this same time Fleischmann<sup>9</sup> wrote concerning anomalies in the position of the colon and in the peritoneal attachments, which, after the examination of many fœtuses of four to seven months of age, he attributed to variations in the development of the intestines. This is the first detailed study of this subject from the standpoint of pathology.

The clinical importance of displacements of the colon received its first adequate emphasis by Esquirol,<sup>10</sup> in 1838, who noted at necropsy 33 displaced coli in 168 cases of melancholia, of which many were the V-shaped transverse colon, now so familiar. The association of this condition with mental derangement had been for many generations a medical tradition, but never previously so well demonstrated.

From the anatomical side, J. Müller<sup>11</sup> in 1830 published an epochal paper concerning the origin of the omentum and the mesentery of the stomach and intestine. This was soon followed by many attempts at detailed descriptions of the abdominal viscera and their peritoneal coverings, of which Huschke's<sup>12</sup> are the most interesting. In 1845, in Soemmerring's "System of Anatomy," he described in considerable detail the ligaments or peritoneal folds about the liver, gall-bladder and duodenum which have collectively and deservedly come to be known as the ligaments of Huschke. In particular he mentions the "ligamentum hepatico-duodenale" and the "ligamentum hepatico-colicum," the clinical significance of which is now being recognized, long after its anatomical recognition had in greater part been forgotten. Huschke also called attention at this time to the fact that the cæcum rarely has any mesentery, a point which has often been reiterated and, as a perusal of the literature on the subject of "cæcum mobile" shows, needs to be still reiterated. He also contributed the first extensive account of the folds and fossæ about the ileum and cæcum.

Meanwhile the interest of the great pathological anatomists, Rokitsky<sup>13</sup> and Virchow,<sup>14</sup> had been aroused, but apparently without proper appreciation of the anatomical work already done.

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<sup>b</sup> For an historical discussion of the literature up to 1879, see Toldt.<sup>6</sup>

The former, in 1842, noted in careful observations on almost innumerable subjects, peritoneal adhesions sufficiently characteristic to enable him to classify them as: between adjacent loops of intestine; between intestine and adnexa; and between intestine and parietal wall. These he presumed to be of inflammatory origin. To Virchow, however, must be given all credit for a most careful and detailed report of such adhesions, in a classical article published in 1853 and intitled "Historisches, Kritisches und Positives zur Lehre der Unterleibsaffectionen." Localized adhesions at the sigmoid flexure, at the left and right colic flexures, about the gall-bladder, duodenum and pylorus, and of the greater omentum to the parietal wall are all here definitely described. The process by which such adhesions were formed was termed "chronische partielle Peritonitis" and led, not infrequently, to kinking, axial rotation and partial obliteration of the intestine. Such peritonitis was supposed to be secondary to an inflammation resulting from the stagnation of fæces, the latter being a result of anomalous positions of the intestine previously described by Esquirol and Fleischmann.

The next contribution of note was made by Engel<sup>15</sup> in 1857, who in a series of papers concerning the cæcum noted abnormal mobility in, roughly, 10 per cent. of some 100 necropsies.

The same year Treitz<sup>16</sup> published the first systematic study of retroperitoneal herniæ with the fossæ and folds involved. This was destined to awaken a virile interest in this topic and to be succeeded by many other treatises of a similar nature. In this monograph he described in considerable detail the fixation of the colon, which he considered to be due, as previous authors had suggested, to the relatively greater growth of the structures in the posterior abdominal wall, thus resulting in the spreading out of the mesenteric leaves and the approximation of the colon to the parietes.

This general principle as enunciated by Treitz reappears again and again in the more recent discussions of the relation of the colon to its peritoneal covering, apparently without knowledge of Treitz's contribution. He also describes in greater detail the subcæcal fossæ to which Huschke called attention and in connection with the descent of the cæcum refers to the presence of a "plica genito-enterica" which has the "Bedeutung eines wahren Leitbandes für den Blindsack und das unterste Ileum." He also suggests that this same fold, which he believes to be a vestige of the descent of the testicle or ovary and to act as a guide and tractor for the descending colon on either side, is the essential factor in the formation of the "Recessus intersigmoideus." Although agreeing with Virchow that many of the adhesions about the colon are inflammatory in origin, he asserts that those in the region of the sigmoid are due to the peritoneal rearrangement involved in the formation of the intersigmoid fossa.

Luschka,<sup>17</sup> in 1861, and Langer,<sup>18</sup> in 1862, wrote concerning the fixation of the colon, and the formation of the folds and fossæ adjacent to the cæcum. The former described the ileocolic fold which properly bears his name,

while the latter discussed in particular the relation of the greater omentum to the colon in respect to its fixation. He was of the opinion that the ligamentum phrenico-lienale, as well as the corresponding fixation of the colon on the right, was derived from the omentum which by its attachment to the parietal wall served to fix the colon. He even went so far as to attribute the position of the fossæ subcæcales and the bands frequently seen in the neighborhood of the sigmoid to this same omental fusion.

Waldeyer,<sup>19</sup> in 1868, discussed Treitz's hypothesis on the basis of numerous observations of his own, and concluded that the development of the fossæ and folds previously described could not be thus easily explained. As for the more unusual bands which he likewise observed, these were considered as perhaps the result of a fetal peritonitis or of some as yet not understood factor.

Gruber,<sup>20</sup> at about this same time, was publishing a series of articles having to do with the anomalies resulting from incomplete development of the intestine and its peritoneum. In these the "mesenterium commune" received its first extensive consideration.

The year 1879 marked the publication of a notable paper by Toldt<sup>5</sup> on the "Bau und Wachstumsveränderungen der Gekröse des menschlichen Darmkanales," the importance of which cannot be too greatly emphasized. The fundamental character of this work can be properly appreciated only by reading the original paper. The description to be given later of the developmental changes in the intestine and mesentery will be founded in large part upon the work of Toldt. Only a few of the points of special interest will be referred to at this time.

Detailed examinations were made of some eleven embryos under six months of age and twenty-four during the last three months of intra-uterine life. Sixty infants under one year of age and fifty-four children from one to twenty years were also examined. He concluded that the mesenteries of the colon disappear by a process of "physiological fusion" of contiguous peritoneal surfaces. The adhesions noted previously by Treitz<sup>16</sup> and Waldeyer,<sup>19</sup> as well as many described by Virchow,<sup>14</sup> were considered to be the result of this process rather than of a fetal peritonitis. The great omentum in either flank serves, by its adherence to the parietal wall and to the intestine, to aid in the process of fixation. The colon and its peritoneal relations after birth show great variations, and developmental changes occur for some time during infant life. The colic omentum on the right may persist as far as the cæcum, become attached to the parietal wall or fused across the hepatic flexure with the great omentum. The ligamenta cæcæ and the fixation of the ileum are the result of developmental variations, and this is likewise true of the not infrequent adhesions observed about the appendix. The hypothesis accounting for the formation of the mesentery by the approximation of two leaves of the peritoneum was entirely refuted as well as that of the fixation of the colon by disproportionate growth and spreading of the mesentery. In short, Toldt described most of the forms of intestinal and

peritoneal aberrations to be discussed in this present paper and referred these to variations in the normal process of development.

In 1885<sup>21</sup> the first extensive consideration in the English literature of the anatomy of the intestinal canal in man was contributed by Treves in the Hunterian Lectures of that year. The development of the intestine immediately after birth was especially considered and valuable data given as to the frequency of occurrence of the ascending and descending mesocoli, mobile cæcæ, etc. The various folds and fossæ of the peritoneum were also discussed, in particular the so-called "bloodless fold of Treves," but with little reference to previous work done on this subject. It is of interest to note his statement that "in not a few specimens the terminal part of the small intestine has been closely attached to the psoas muscle, not by direct adhesion but by a fold of peritoneum." This work was peculiarly fortunate in appearing within a year of Fitz's elucidation of appendicitis and provided very valuable data in the English literature covering the anatomical problems presented by this condition.

The studies of Treitz, Luschka, Waldeyer, Treves, and many others in respect to retroperitoneal herniæ, together with a large amount of personal work, were embodied by Jonnesco<sup>22</sup> in a monograph entitled "*Hernies internes retro-péritonéales*," published in 1890. This in conjunction with a second article by the same author in 1894,<sup>23</sup> dealing more particularly with the folds and fossæ about the appendix and ileum, comprises a complete exposition of this subject. He is unusually conscientious in his references to work previously done.<sup>c</sup>

Klaatsch,<sup>24</sup> in 1892, wrote concerning the morphology of the mesentery and its development in the vertebrates. This forms the first extensive account from the standpoint of comparative anatomy and with Huntington's<sup>27</sup> monograph (1903) serves to corroborate and correlate the findings of Toldt with the changes noted in the lower animals. Mall,<sup>28</sup> in 1897, by accurate reconstruction studied the development of the intestine and mesentery in the embryo very early in life, thus filling in a gap in the work of Toldt.

Lockwood and Rolleston,<sup>29</sup> in 1892, investigated 160 bodies in which there was no peritonitis or sign of local inflammation. Of these 23 per cent. were found to show adhesions of the appendix to neighboring structures, referable to abnormalities of development. The hypothesis of Treitz that the plica genito-enterica acts on the cæcum as a tractor to guide it into position was for the second time<sup>30</sup> advanced by this author with no reference to work previously done.

Addison,<sup>31</sup> in 1900, studying the intestine and mesentery in 40 cadavers, supplied additional data as to the frequency of occurrence of already well-

<sup>c</sup> Shorter but admirable discussions of this same topic are available in the English literature, notably Moynihan's<sup>32</sup> "*Retroperitoneal Hernia*" (1906) and Berry's<sup>33</sup> "*The Cæcal Folds and Fossæ and the Topographical Anatomy of the Vermiform Appendix*" (1897).

recognized variations of the intestine. Another contribution of the same nature was made by Byron Robinson <sup>32</sup> in 1902. Both of these writers dealt in detail with abnormal mobility of the cæcum and colon and with the bands and ligaments of peritoneum which are at present under discussion, and the former very specifically describes the hyperfixation of the ileum now known as Lane's band.

At about this period, from the clinician's viewpoint, pain in the right lower abdomen came to mean appendicitis—if unaccompanied by acute illness "chronic appendicitis"—and most surgeons and many pathologists assumed the membranes not infrequently seen about the intestines on this side of the abdomen to be the residuum of an appendicitis.

It is true that some unusually keen observers had begun to suspect that such membranes might give symptoms of themselves, identical with those of "chronic appendicitis." Riedel, as early as 1894,<sup>33</sup> called attention to this, and in later papers, in 1897,<sup>34</sup> and 1898,<sup>35, 36</sup> again and again in great detail described omental, gall-bladder, appendiceal, colonic and ileal membranes in connection with colicky pain and other symptoms of partial obstruction. These descriptions were particularly accurate and his work deserves greater credit than has as yet been given it. He thought that in the new-born such structures might occur as a primary developmental error, but that in the adult it was quite probable that they might arise from chronic inflammation. Riedel also considered that such membranes might be due to the dragging of the colon upon the mesentery, with the rupture of supporting fibres, and their accentuation by the consequent repair. He thus antedated all the present hypotheses by several years.

In 1893, Lauenstein,<sup>37</sup> whose attention had been attracted by the work of Riedel, reported many cases with the symptomatology of "chronic appendicitis" in which he found membranes about the gall-bladder, ascending colon and particularly the ileum, of which he gave diagrammatic sketches. He reported surgical treatment of these bands and membranes with cures thereby.

A new phase of the subject was introduced by Curschmann <sup>38</sup> in 1894, who described several cases in which the cæcum was turned upward with a sharp kink, causing partial obstruction, in his mind the cause of this being anomalies of the mesentery of the colon.

Although Riedel referred to adhesions on the left side of the abdomen, it remained for Gersuny,<sup>39</sup> in 1899, to call adequate attention to their frequency and their significance. He noted that patients giving the symptoms and signs of a "chronic appendix" on the left side of the abdomen, frequently showed at operation adhesions about the sigmoid flexure, and that the release of these, in some cases, effected a cure. Their origin might be from an old appendicitis with healed peritonitis, from inflammation of the adnexa, or from the rupture of ovarian follicles and resultant hæmatomata in this region.

Likewise, Quénu,<sup>40</sup> in 1902, covering more intensively some of the ground

previously considered by Riedel, discussed stasis at the left colic angle as a result of omental adhesions stretching across it, a subject which was to be even more extensively considered by Payr in 1905,<sup>41</sup> the latter supposing them to be the result of chronic inflammation. In a second paper<sup>42</sup> in 1913 he, however, recognizes the congenital type as well.

Tavel,<sup>43</sup> in 1904, reported instances of adhesions over the ascending colon and with the omentum where the "cæcum vagabundum" of Roux was present. The diagrammatic pictures accompanying this article well illustrate what is now known as "Jackson's membrane." In 1905 appeared the first case report in the American literature of this type of a lesion (Binnie<sup>44</sup>). Apparently, however, no great importance was laid upon the presence of this membrane either by the author or by his readers.

In 1905, also, Corner and Sargent<sup>45</sup> published in this country five cases of volvulus of the cæcum (cæcum mobile) with a collection from the literature of 52 similar lesions. Dilatation from partial obstruction was present and at times gave rise to symptoms suggestive of appendicitis.

At this same time a paper by Hockenegg<sup>46</sup> emphasized the importance of appendiceal colic as distinguished from appendicitis, and the result of abnormal fixation of the appendix, probably congenital. This condition corresponded with the "appendicitis larvata" of Ewald or the "pseudo-appendicitis" of Nothnagel.

Meanwhile Wandel,<sup>47</sup> in 1903, in 640 necropsies had paid particular attention to the position of the cæcum and the presence of abnormal mobility, especially with reference to kinking, torsion or marked displacement. In 66 of these the cæcum was mobile, 28 being in children, an incidence distinctly higher than in the adult.

During this time surgical experience as regards the appendix was becoming crystallized. The rapid method of operating through a "button-hole" incision was falling into disrepute, in part because such procedure did not allow of a satisfactory exploration of the abdomen for lesions, such as cholecystitis or peptic ulcer which might simulate a chronic appendicitis. It also began to be noted by observers whose object was the ultimate condition of the patient rather than the success of the immediate operative procedure that in many instances the symptomatology of "chronic appendicitis" was followed by the discovery at operation of a normal appendix and that the removal of this organ usually failed to alleviate the symptoms of which the patient originally complained. Such a general impression was confirmed by statements of end-results by such surgeons as Haberer<sup>48</sup> and Klemm.<sup>49</sup>

Haberer, in 1905, reported 116 cases with the clinical diagnosis of "chronic appendicitis," in 40 of which the removal of the appendix did not relieve symptoms. Many of these showed at operation membranes about the cæcum and colon which he supposed to be the result of an appendicitis or cholecystitis, usually the former.

Two years later Klemm called attention to "anfallsfreie Appendicitis,"

in connection with which he observed membranes about the cæcum and colon and dilatation of the cæcum. Like Haberer, he ascribed these conditions to inflammation of the appendix, but noted that in many instances removal of this supposedly diseased organ did not effect a cure. Albu<sup>50</sup> at this same time reported cases of "chronic appendicitis" in which the appendix was normal. He thought the pain possibly due to kinking of the appendix.

Such observations were by no means unusual, and from 1905 to the present time the history of this topic presents a medley of descriptions and hypotheses of various abnormal structures described and discussed by numerous workers, many of them in apparent ignorance or with inadequate appreciation either of what had been done previously on this subject or of what was being done elsewhere at the time. The springing up of such a crop of observations served to demonstrate, however, the general opinion as to the inadequacy of our knowledge concerning the conditions which may simulate the so-called "chronic appendicitis."

In analyzing the work accomplished in the past ten years one finds that it falls naturally into three groups, of which Wilms in Germany, Lane in England, and Jackson in this country may be taken as the representatives. These men have served to call attention to facts well recognized previously but not properly emphasized from the clinical point of view, and they deserve much credit for thus attracting the attention of the profession to this subject.

Lane<sup>51</sup> as early as 1903 began to discuss the presence of membranes about the colon and ileum, and their significance in chronic intestinal stasis. With the development of his interest in this subject, successive papers and monographs have appeared,<sup>52, 53, 54, 55, 56, 57, 58</sup> the latest being but a statement of his position, which reached its fullest development from 1908 to 1911. His attitude toward the etiology of these structures seems to have been largely determined by his early studies on the adaptation of tissues to increased work, as in the bony attachments of muscles, and from this he has evolved the idea that the membranes and bands about the colon are but an evolutionary response to the erect position, which results in a "crystallization of the lines of strain." His extreme enthusiasm as to his operative results has served to call attention to a subject which perhaps otherwise would have been for a long time neglected.

During the same period Wilms<sup>59, 60, 61</sup> was attacking the problem over a smaller field, and from a somewhat different angle, this being also apparently determined by early work of his on the sensitiveness of the peritoneum and mesentery to pain. The pain observed in the so-called "chronic appendicitis" seemed to him referable to the dragging on the mesentery by an unduly movable cæcum, and an investigation of this in the course of operations for "chronic appendicitis" provided material for his report of 40 cases of "cæcum mobile" operated upon with fixation of the cæcum and with good results. This publication aroused much interest and considerable discussion in Germany, and led to the publication of valuable papers by Fischler<sup>62</sup> on "typhlatonie," Klose<sup>63, 64</sup> on "habitual torsion," and Stierlin,<sup>65</sup> who in 1910 reviewed the work in Wilms' clinic.



Meanwhile, Jackson,<sup>66</sup> in 1908, had described in detail a case of "chronic appendicitis" with a veil-like membrane over the ascending colon. Similar structures were almost immediately noted by many abdominal surgeons and the literature for the next few years teems with descriptions of these.

Hofmeister,<sup>67</sup> in 1911, viewed the subject from a point that at that time was receiving its greatest attention in America; namely, the presence of adhesions about the colon. The greater number of the laparotomies performed for chronic abdominal pain, in his opinion, revealed a healed acute appendix which had never given the symptoms of an appendicitis, the "anfallsfreie Appendicitis" of Klemm. There might be microscopically or macroscopically no sign of inflammation in the appendix, but the membranes over the colon and about the cæcum were taken to be evidence of such a condition in the past. Moreover, these bands, according to Hofmeister, were capable of producing dilated and mobile cæcæ subject to torsion and kinking. In short, the process, in his mind, was definitely inflammatory following a colitis, or appendicitis and a consequent pericolitis. In the same year Dreyer<sup>68</sup> in 105 autopsies reported 67 per cent. of movable cæca and furnished a complete review of the literature on "cæcum mobile."

It was at once apparent that the determination of the etiology of these structures had an important bearing on the treatment to be adopted, and consequently nearly every writer has ventured an opinion on this particular phase of the subject. The simplest explanation, and the one for a time most frequently offered, attributed the condition to inflammation. An appendicitis, or a colitis, or a primary pericolitis was presumed to have been the etiological factor by Gerster,<sup>69, 70</sup> Frazier,<sup>71</sup> Morris,<sup>72</sup> Coffey,<sup>73</sup> Martin,<sup>74</sup> Bevan,<sup>75</sup> Cuneo,<sup>76</sup> Eastman,<sup>77</sup> and by Pilcher<sup>78</sup> in his first paper.

On the other hand, C. H. Mayo<sup>79</sup> early pointed out that both the "Jackson membrane" and the "Lane band" were probably congenital, and Connell<sup>80</sup> reviewed the development of the intestines and peritoneum, showing the variations which these structures represented. It remained, however, for Flint,<sup>81</sup> in 1912, to show conclusively that such structures observed in the operating room were identical with certain peritoneal malformations found with great frequency in the foetus. At the same time Gray and Anderson<sup>82, 83</sup> reported similar observations in the foetus and arrived at the same conclusions.

Meanwhile, Douglas Reid<sup>84, 85, 86, 87</sup> had been reporting many variations of the normal peritoneal folds in cadavers, some of foetuses, studied by him. These observations were in fact but repetitions of similar findings reported by many anatomists in previous years, but coming at this time they served to form the basis of a further development of the congenital theory which supposes these membranes and bands to be but modifications of folds previously described. "Jackson's membrane" becomes "Jonnesco's parietocolic fold," adhesions about the cæcum "Treves' bloodless fold," and "Lane's band" "Reid's genito-mesenteric fold." Cheever<sup>88</sup> and Eastman<sup>77</sup> in particular have emphasized this phase of the subject.

More recently W. J. Mayo,<sup>89</sup> Morley,<sup>90, 91</sup> Barling,<sup>92</sup> Summers,<sup>93</sup> Moynihan,<sup>94</sup> and Eisendrath and Schnoor<sup>95</sup> have stated that these membranes are congenital. Morley and Eisendrath and Schnoor in particular based their opinion upon the findings of these structures in foetuses and infants. Leveuf,<sup>96</sup> in France, has also called attention to the presence of such structures in the foetus and again to the persistence of the colic omentum of Haller and its relationship with the formation of membranes about the ascending colon. Keith<sup>97</sup> has approached the problem from quite a different angle, and states that, the adhesive process being an embryonic property, variations in this process resembling adhesions are not surprising. Such variations, however, in his opinion, have but little influence on the normal function of the gut. Stasis is due not to these structures, but rather to a loss of function of certain ganglionic centres in the wall of the intestine normally responsible for its peristalsis.

In spite of the preponderance of evidence already offered by the advocates of the congenital formation of these membranes, it seemed worth while to supplement the data of Flint, Gray and Anderson, Morley and Leveuf by the examination of the intestine and peritoneum in a large number of infants shortly after birth, and especially with a view to relations of the membranes to each other, to the mobile cæcum, to sex, and to the age of the infants. It was assumed, for reasons which will be discussed fully later, that any variations from the normal in the position of the gut and its peritoneal attachments seen at this age might be considered as arising from variations during the development of these structures.

For a proper appreciation of the data presented, it is necessary to have clearly in mind the developmental history of the peritoneum and intestine and their relations to adjacent structures at varying periods of embryonic life.

### III. DEVELOPMENT OF THE INTESTINE

At about the sixth week of intra-uterine life the alimentary canal has reached a stage of development indicated in Fig. 1. The stomach and intestine lie in the midline, the greater diameter of the former being directly anteroposteriorly, and the latter projecting forward toward the umbilical cœlum from which it has just been withdrawn.

At about the third month we find certain important changes taking place. The stomach undergoes a rotation by which its greater curvature comes to lie toward the left, and its lesser toward the right, the peritoneal attachment of the latter thus forming the hepatico-gastric omentum. The duodenum likewise undergoes a similar rotation and, in addition, the posterior layer of its mesentery, by a process of fusion with the peritoneum of the posterior abdominal wall, becomes fixed. The rapid growth of the intestine has meanwhile carried the cæcal bud upward into the upper part of the abdomen and the condition is now that represented in Fig. 2. By the fourth month the growth of the portion of the colon which will shortly become the ascending and transverse colon has carried the cæcal pouch upward and to the right. With this there is a consequent rotation upon its

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own axis, so that the ileum, which has previously entered from above and to the right, now is seen below and to the left of the cæcum (Fig. 3).

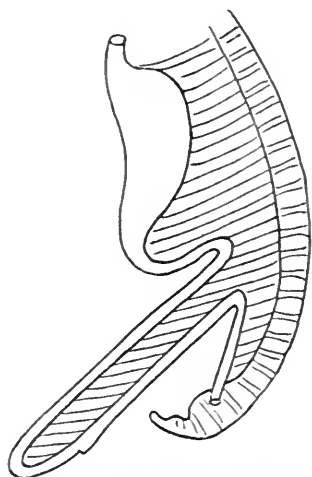


FIG. 1.—Intestine of fœtus at about sixth week (after Toldt).

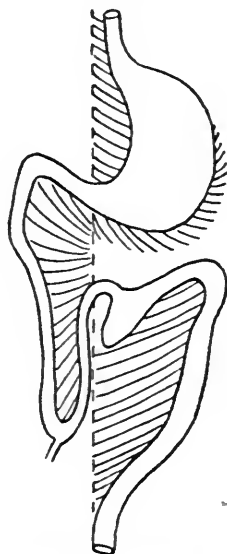


FIG. 2.—Intestine of fœtus at about third month (after Toldt).

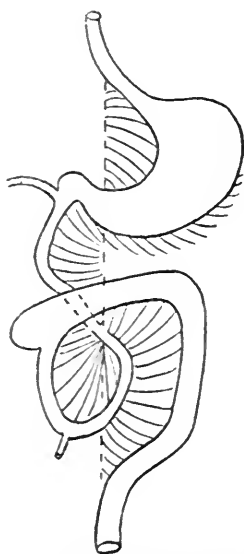


FIG. 3.—Intestine of fœtus at about fourth month (after Toldt).

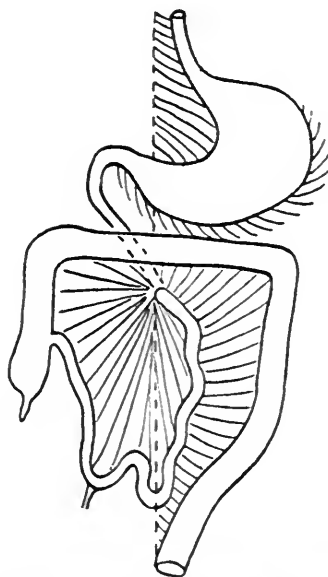


FIG. 4.—Intestine of fœtus at about eighth month.

Toward the end of this month the process of fusion of the mesentery is rapidly accentuated, the mesocolon at the hepatic and splenic plexus disap-

pearing and the great omentum which has been formed by a bulging of the posterior mesogastrium becomes attached along the transverse colon and at times over the ascending colon and cæcum even to the appendix (Toldt and Prenant). This reaches its highest point at about the seventh month. From this time until birth fusion progresses slowly with the gradual disappearance of the ascending and descending mesocoli. The cæcum meanwhile at about the sixth month has reached the right kidney and at about the eighth month the right iliac fossa (Fig. 4).

It should be borne in mind that, as will be shown later, all these processes, but especially those most active in the later months of intra-uterine life, are extremely variable and may be retarded so that the full development is not reached until several months after birth (Toldt).<sup>d</sup>

There are then four processes involved in the development of the colon as seen at birth; namely, migration, axial rotation, descent and fixation. As Prenant states, variations of these processes may be "*par excès et par défaut*," and in the following classification, which corresponds in large part with that of Connell,<sup>101</sup> such an arrangement is used.

#### IV. CLASSIFICATION AND DATA

Migration: (a) Deficient, (b) excessive.

Rotation: (a) Deficient, (b) excessive.

Descent: (a) Deficient, (b) excessive.

Fixation: (a) Deficient, (b) excessive.

In the appended table giving the essential data concerning the cases examined, these variations are classified according to this outline, and they will be discussed in detail under these headings.<sup>e</sup>

#### V. VARIATIONS OF MIGRATION

The process of migration extends over a period of three months or more, early in foetal life; that is, from about the first to the fifth month, when descent begins, and during this time the cæcum passes from the

<sup>d</sup> For a more detailed discussion of the development of the intestine and its mesentery see Toldt,<sup>6</sup> Broesike,<sup>98</sup> Hertwig,<sup>99</sup> and Prenant.<sup>100</sup>

<sup>e</sup> The age is expressed in numbers representing the year, month and day respectively. For instance, 1-7-14 represents one year, seven months and fourteen days. Wherever this number is asterisked it represents an approximation of the age, necessary because of deficient hospital records, and should be read as follows: 0-6-0—not over six months of age. Wherever the diagnosis is placed within quotation marks this signifies that a complete necropsy was not done, that there was no pathological condition within the abdomen and that this represents the clinical diagnosis. The variations when present are marked \*, and signify a kink in the gut as well. Variations of migration and rotation are not included in this table, as they are so few that it is not worth while tabulating them. They are discussed under their appropriate headings. The terms "hypodescent" and "hyperfixation," etc., although not ideal from the standpoint of derivation, are convenient and will be used throughout the remainder of this paper. The headings under hyperfixation refer to the location of the adhesions and are explained in

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umbilical coelom into the abdomen, then upward and to the right until it comes to lie in the right hypochondrium. Variations from this procedure might be theoretically of two types: the intestine might remain in whole or in part without the abdominal cavity or pause at any point along the route (deficient migration); or it might move downward prematurely into its adult position (excessive migration). The latter could only be detected by examination previous to the time of normal descent and consequently does not appear in these data. The former, in which the cæcum may be found in the left side of the abdomen or even in a congenital umbilical hernia, is exceedingly rare and was not observed in this series of cases. Smith,<sup>103</sup> however, reports five instances of deficient migration in the course of 1050 autopsies on infants, or in one-half of one per cent., and the condition is, of course, a matter of common surgical knowledge.

### VI. VARIATIONS OF ROTATION

The process of rotation is practically synchronous with that of migration, and consists in the turning of the gut upon its longitudinal axis in such a manner that the ileum enters the large intestine on its left side, whereas previously it entered on the right. The variations in this process which are theoretically possible are: (a) deficient rotation, (b) excessive rotation. In the former case the ileum would enter from the right and posteriorly, and in the latter anteriorly. One instance of deficient rotation was observed in this series, occurring in a female under one month of age in whom no cause of death was found (No. 319). It was associated with lack of fixation of the colon but with no other variations from the normal.

This condition is rarely observed, perhaps because the possibility is not borne in mind by either the surgeon or the pathologist. Nevertheless Connell<sup>101</sup> was able to collect four cases from the literature, to which he added two of his own. The same is true of excessive rotation, of which no instance was noted in these reports. In both deficient and excessive rotation, when combined with fixation, the ileum can hardly escape being kinked.

### VII. VARIATIONS OF DESCENT

The process of descent is late in its completion, starting at about the fifth month and probably not reaching a final adjustment until four months after birth, although at eight months, according to Hertwig<sup>99</sup> and Prenant,<sup>100</sup> the cæcum is usually in what corresponds to the adult position. This is said

detail in the text. It is at once apparent on examination of this table that certain coli are classified as showing both hypofixation and hyperfixation. It is necessary to remember that the term "fixation" is used here to represent what may be termed the embryological process of physiological fusion of the peritoneal layers, which is more properly called zygoxis by Keith. So one may find a colon with a mesentery, representing hypofixation and with the peritoneum drawn out into bands or a veil which represents a hyperfixation, that is to say an exaggeration of the process of peritoneal fusion in this particular area. These apparent contradictions will be more fully discussed later. For a full definition of each of these subheadings see the respective sections.

TABLE OF VARIATIONS OF DESCENT AND FIXATION

No.	Sex	Age	Diagnosis	Variation in									
				Descent		Fixation							
				Hypo-	Hyper-	Hypo-	Cystocolic	Hepatic-flexure	Pericolic	Pericæcal	Appendicular	Ileal	
212	F	0-9-21	Tuberculous pneumonia. Rhachitis	-	+	+	-	-	-	-	-	-	-
214	M	0-3-19	Bronchopneumonia	-	-	-	-	-	-	-	+	-	-
215	F	0-3-7	Malnutrition. No cause of death found	-	-	-	-	-	-	-	+	-	-
216	M	0-1-21	Bronchopneumonia. Malnutrition	-	+	-	-	-	-	-	+	-	-
217	F	1-0-0	Follicular colitis. Rhachitis	-	+	-	-	-	-	-	-	-	-
220	F	0-0-18	Bronchopneumonia. Malnutrition	-	+	-	-	-	-	-	-	-	-
223	F	0-1-29	Bronchopneumonia	-	+	-	-	-	-	-	-	-	-
224	F	0-1-7	Ileocolitis	-	+	-	-	-	-	-	-	-	-
225	F	0-10-1	Bronchopneumonia. Rhachitis	-	+	-	-	-	-	-	-	-	-
226	M	.....	"Marasmus"	-	+	-	-	-	-	-	-	-	-
227	F	0-1-5	Bronchopneumonia. Malnutrition	-	+	-	-	-	-	-	-	-	-
229	M	1-3-13	Bronchopneumonia. Adrenal hemorrhage	-	+	-	-	-	-	-	-	-	-
230	M	.....	.....	-	+	-	-	-	-	-	-	-	-
231	F	0-1-1	Malnutrition	-	+	-	-	-	-	-	-	-	-
232	M	1-7-14	Pyæmia. Fracture of mandible	-	-	-	-	-	-	-	-	-	-
233	M	0-10-28	Bronchopneumonia. Ulcerative enterocolitis	-	-	-	-	-	-	-	-	-	-
234	F	0-3-11	Malnutrition	-	-	-	-	-	-	-	-	-	-
239	F	0-8-12	Tuberculous pneumonia	-	-	-	-	-	-	-	-	-	-
241	F	0-7-10	Bronchopneumonia. Rhachitis	-	+	-	-	-	-	-	-	-	-
242	M	1-1-16	Bronchopneumonia. Rhachitis	-	+	-	-	-	-	-	-	-	-
243	M	0-6-0	Bronchopneumonia. Rhachitis	-	+	-	-	-	-	-	-	-	-
244	F	0-6-0	.....	-	+	-	-	-	-	-	-	-	-
245	M	1-0-0*	Bronchopneumonia. Rhachitis	-	+	-	-	-	-	-	-	-	-
246	M	0-0-25	"Marasmus"	-	+	-	-	-	-	-	-	-	-
247	F	1-6-0*	Bronchopneumonia. Follicular colitis	-	+	-	-	-	-	-	-	-	-
248	F	0-2-16	Malnutrition	-	+	-	-	-	-	-	-	-	-
249	M	0-4-21	Generalized miliary tuberculosis	-	+	-	-	-	-	-	-	-	-
250	F	0-7-25	No cause of death found	-	+	-	-	-	-	-	-	-	-
251	M	0-3-0	"Marasmus"	-	+	-	-	-	-	-	-	-	-
252	F	0-0-21	"Marasmus"	-	+	-	-	-	-	-	-	-	-

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[illegible]

TABLE OF VARIATIONS OF DESCENT AND FIXATION—Continued

No.	Sex	Age	Diagnosis	Variation in									
				Descent		Fixation							
				Hypo-	Hyper-	Hypo-	Cystocolic	Hepatic-flexure	Pericolic	Pericaecal	Appendicular	Ileal	
308	F	0-1-15	Bronchopneumonia. Congenital syphilis.	-	-	-	+	-	-	-	-	+	9
309	M	0-0-20	Malnutrition.	-	-	-	-	-	-	-	-	-	8
312	M	0-1-6	No cause of death found.	-	-	-	-	-	-	-	-	-	17
314	F	0-1-16	No cause of death found.	-	-	-	-	-	-	-	-	-	13
315	M	0-0-26	No cause of death found.	-	-	-	-	-	-	-	-	-	10
316	M	0-8-8	Bronchopneumonia.	-	-	-	-	-	-	-	-	-	20
319	F	0-1-0*	No cause of death found.	+	-	-	+	-	-	-	-	-	14
321	M	0-6-0	Bronchopneumonia.	-	-	-	-	-	-	-	-	-	22
322	F	0-3-27	Bronchopneumonia.	-	-	-	-	-	-	-	-	-	1
323	F	1-6-0*	Bronchopneumonia. Rhachitis.	-	-	-	-	-	-	-	-	-	105
324	F	0-2-17	Malnutrition.	-	-	-	-	-	-	-	-	-	
325	F	0-1-15	No cause of death found.	-	-	-	-	-	-	-	-	-	
329	F	0-10-27	Abscess of lung.	-	-	-	-	-	-	-	-	-	
330	M	0-2-4	Subperiosteal abscess of mandible.	-	-	-	-	-	-	-	-	-	
331	M	0-0-14	Subdural hemorrhage.	-	-	-	-	-	-	-	-	-	
332	M	0-0-19	Bronchopneumonia.	-	-	-	-	-	-	-	-	-	
333	F	0-2-0*	No cause of death found.	-	-	-	-	-	-	-	-	-	
334	F	0-6-0	Bronchopneumonia.	-	-	-	-	-	-	-	-	-	
336	M	0-3-0	No cause of death found.	-	-	-	-	-	-	-	-	-	
337	F	0-2-24	Bronchopneumonia.	-	-	-	-	-	-	-	-	-	
343	F	0-4-13	Rhachitis.	-	-	-	-	-	-	-	-	-	
345	M	0-9-8	Bronchopneumonia.	-	-	-	-	-	-	-	-	-	
348	F	0-3-3	Malnutrition.	-	-	-	-	-	-	-	-	-	
349	M	0-2-0	Bronchopneumonia. Rhachitis.	-	-	-	-	-	-	-	-	-	
351	M	0-5-3	Bronchopneumonia. Rhachitis.	-	-	-	-	-	-	-	-	-	
352	F	0-5-18	Bronchopneumonia.	-	-	-	-	-	-	-	-	-	
356	M	0-3-0	Malnutrition.	-	-	-	-	-	-	-	-	-	
357	F	0-6-0	Bronchopneumonia. Peribronchial abscesses.	-	-	-	-	-	-	-	-	-	
360	M	0-3-0	Purulent bronchitis.	-	-	-	-	-	-	-	-	-	
361	F	0-6-0*	Congenital syphilis.	-	-	-	-	-	-	-	-	-	
			Total 105.....	1	22	14	20	10	17	13	8	9	



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to be "in the right iliac fossa resting on the iliac fascia covering the iliopsoas muscle above the outer part of Poupart's ligament about half below and half above the level of the anterior iliac spine" (Piersol<sup>102</sup>). If one takes this description literally the variations outnumber the normal. Such minor variations, however, are of no importance either anatomically or surgically, and it is only the marked variations that have been noted in these examinations.

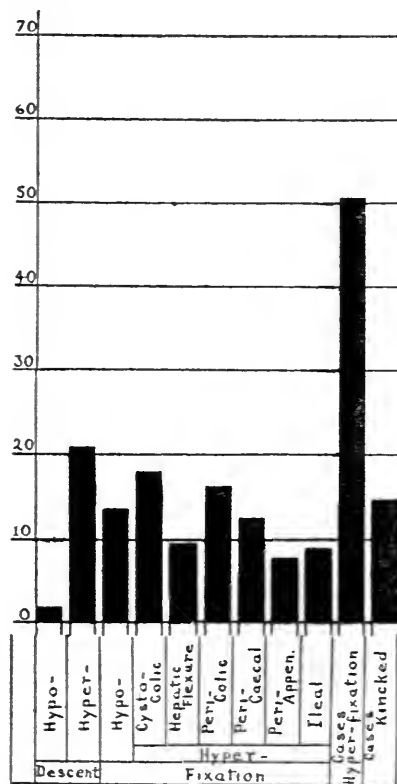


FIG. 5.—Incidence of peritoneal variations in 105 infants shown by percentage.

There are again two possible types of variations from the normal, namely, (a) deficient descent (hypodescent), and (b) excessive descent (hyperdescent), under which titles these will be discussed.

(a) *Hypodescent*.—This term should cover instances in which the cæcum lies anywhere between the region of the liver and its normal position, but in this group of cases this condition was noted only when the cæcum had failed to descend at all; that is to say when it continued to lie in the right hypochondrium. Only two such instances were observed and these are too few to draw any definite conclusions as to its association with other variations.

Smith,<sup>103</sup> in his series of 1050 autopsies on infants, found 63, or 6 per cent., in which the cæcum lay between the liver and the right iliac crest.

Using much the same standard, Byron Robinson<sup>32</sup> reported 25, or 8 per cent., in 310 males, and 5, or 4 per cent., in 125 females, or about 7 per cent. in all the cases. Treves<sup>21</sup> reported the undescended cæcum in 2 per cent. of his observations, this meaning in all probability that the cæcum lay just beneath the liver. Alglave<sup>104</sup> in 100 subjects, of which 50 were male and 50 female, found the ileocæcal segment in the lumbar situation in 3 per cent. It can be concluded, then, that in about 2 per cent. of all cases the

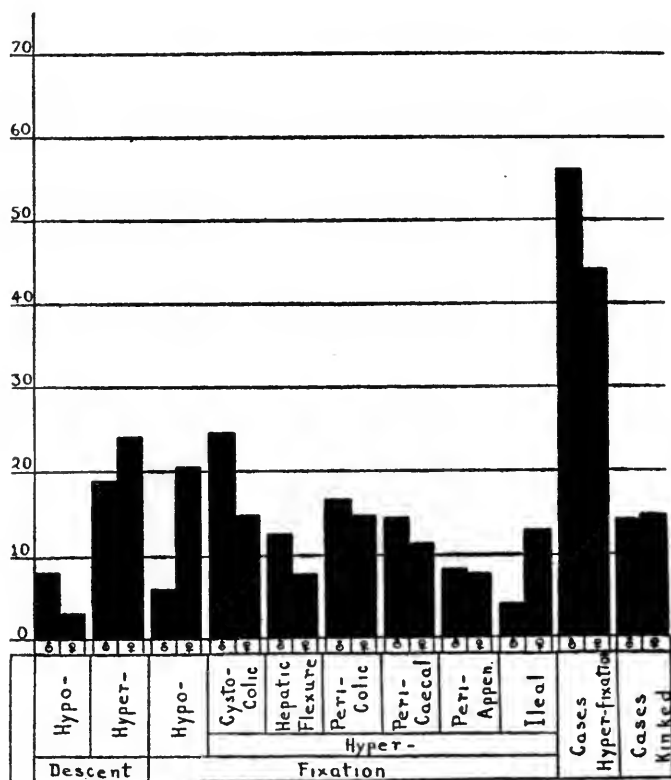


FIG. 6.—Incidence of peritoneal variations in 105 infants according to sex shown by percentage. ♂ = male; ♀ = female.

cæcum may be found in the right hypochondrium and in about 6 per cent. lying between there and its normal position in the right iliac fossa.

(b) *Hyperdescent*.—The cæcum may continue in its descent passing from its normal position, as defined above, into the pelvis, or develop such length and freedom of movement that it is possible for it to lie in the pelvis. Such instances were noted as cases of hyperdescent, and in the 105 examinations this condition was found in 22, or in about 21 per cent. (Fig. 5), of which 8 were in males and 13 in females (Fig. 6).

The following table shows the frequency of this variation as found by various observers:

# PERITONEAL RELATIONS OF ASCENDING COLON

Name.	No. of cases.	Per cent.	†Per cent.	‡Per cent.	Remarks.
Engel <sup>18</sup> .....	100	8	..	..	Necropsy
Lockwood <sup>30</sup> .....	200	18	..	..	At operation
Robinson <sup>22</sup> .....	435	13	10	20	Necropsy
Smith <sup>103</sup> .....	1050	10	..	..	Necropsy (infants)
Tuffer and Jeanne <sup>105</sup> .....	..	16	..	..	Necropsy
Alglave <sup>104</sup> .....	100	23	17	30	Necropsy
Harvey.....	105	21	18	24	Necropsy (infants)

It is of interest to ascertain whether the frequency of hyperdescent increases or decreases as the infant grows older, as in this way we can arrive at some idea as to when the cæcum reaches its adult position and relations. This is done by dividing the necropsies into three age periods and determining the frequency in each period <sup>f</sup> (Fig. 7). By reference to this table it is seen that there is a quite remarkable increase in the frequency of this condition for the first 3 to 6 months. This agrees with the observation of Treves that the large intestine increases rapidly in length during the first few months of extra-uterine life. It may be argued that with the lengthening of the body and the other changes incident to maturity the cæcum may resume its normal position. That this is not so is shown by reference to the statistics of Lockwood and Robinson in adults quoted above, which agree so closely with ours that one must conclude that there is retrogression of this process.

Hyperdescended cæca may be divided into two groups, depending upon whether the colon is attached to the parietal wall (normal fixation) or has a mesentery (hypofixation). Of the former there are 17, or 77 per cent., of the cases of hyperdescent, the remainder, or 23 per cent., being associated with hypofixation of the colon (Fig. 8). This is of considerable interest, inasmuch as it is frequently assumed that a cæcum lying in the pelvis is evidence of ptosis of the viscera, while the above demonstrates that something over three-fourths have their normal support from the attachment of the colon to the abdominal wall and are examples of a true overgrowth. As further evidence of this the fact may be noted that practically none of the infants here cited lived to assume the erect posture. This being so, it is probable that many instances of hyperdescent combined with hypofixation of the colon are as well instances of overgrowth.

It is of interest to ascertain if there is any correlation between hyperdescent and the formation of the various membranes classified under hyperfixation. Such a comparison indicates that hyperdescent does not involve any marked increase or decrease in the presence of accompanying membranes or bands about the colon.

It was not responsible in itself for any kink or angulation of the gut.

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<sup>f</sup>It is realized that the limited number of cases examined renders the data and conclusions derived therefrom by no means accurate. It seemed advisable, however, to attempt an analysis, inasmuch as the results obtained, if not entirely conclusive, are highly suggestive.

VIII. VARIATIONS OF FIXATION

The process of fixation of the large intestine is that of a "physiological fusion" of contiguous peritoneal surfaces, technically known as zygosia (Keith). A deficiency of this process may be termed azygosia or hypofixation, and one of the results of this deficiency is the presence of a mesentery of the ascending colon. When very marked, this results in the well-known mesenterium commune. An excess of fixation may be termed hyperfixation, and consists of the fusing together of peritoneal surfaces

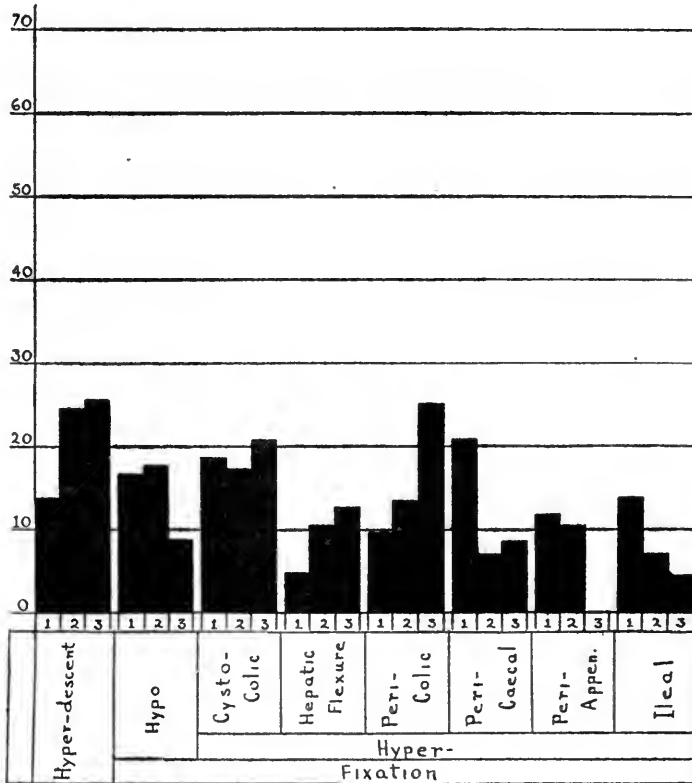


FIG. 7.—Incidence of peritoneal variations in 105 infants according to age shown by percentage. Group I=first two months of extra-uterine life; group II=third, fourth and fifth months of extra-uterine life; group III=the remaining necropsies falling between six months and eighteen months, one being three years and seven months of age.

normally separated. This latter may take place along the entire course of the ascending colon or, as is the case more frequently, at certain portions of it, and does not in this discussion necessarily mean adhesions from the gut to the parietal wall, but includes those stretching between adjacent loops of the intestine, and even the thickened and striated appearance of the peritoneum, so frequently seen covering the mesentery of the ascending colon. These last structures represent an excessive peritoneal fusion, relative to the freedom allowed by the mesentery, and a consequent thickening as a result

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of the uneven strain thrown upon the peritoneum during the further developmental changes (Riedel, Lane, etc.).

(a) *Hypofixation*.—Since the early anatomists a mesocolon on the right has been recognized many times, and following Treves' studies it has become a matter of common knowledge that a mesocolon may be frequently found on either the ascending or the descending coli. The following table gives the

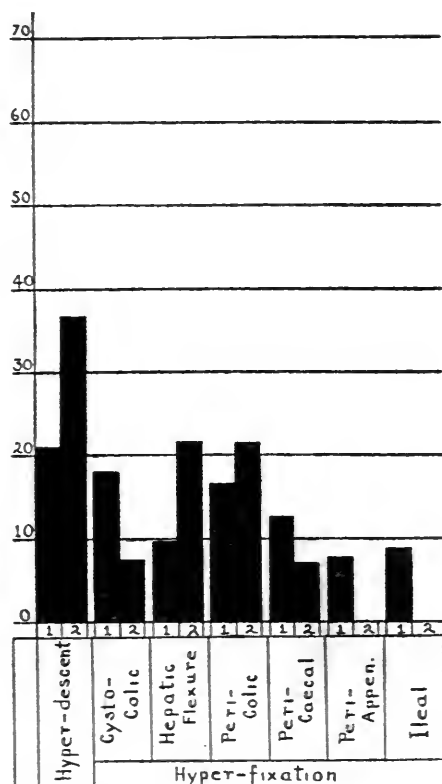


FIG. 8.—Incidence of peritoneal variations in the entire series (1) and in hypofixation (2), compared by percentage.

frequency of a mesentery on the right side as determined by several investigators:

Name.	No. of cases	Per cent
Treves <sup>21</sup> .....	100	26
Addison <sup>21</sup> .....	40	15
Smith <sup>103</sup> .....	982	31
Fallon <sup>104</sup> .....	100	24
Piersol <sup>105</sup> .....	35	14
Dreicka <sup>107</sup> .....	640	23

In this study, under the term "hypofixation," those instances were included in which there was a mesentery of at least the lower two-thirds of the

descending colon. In the 105 necropsies a mesocolon on the right side was found in 14, or in 13 per cent. (Fig. 5). Of these 3, or 6 per cent., were in males and 11, or 20.4 per cent., in females (Fig. 6). This seems to indicate a later fixation of the intestine in the female than in the male, and corresponds with the observations of Klose<sup>63</sup> and Wilms<sup>59</sup> as regards the greater frequency of the "cæcum mobile" in the female.

As regards the time of cessation of fixation, reference to Fig. 7 indicates that even after the sixth month of intra-uterine life this process is still in

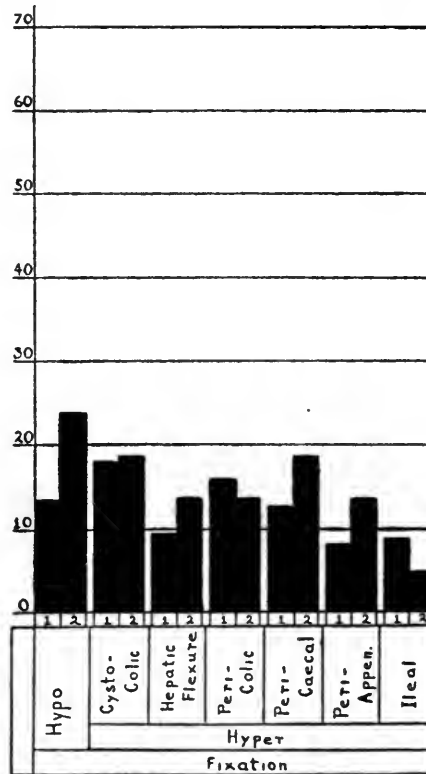


FIG. 9.—Incidence of peritoneal variations in the entire series (1) and in hyperdescent (2) compared by percentage.

progress; it is then a somewhat later process than the descent of the cæcum, which reaches a state of equilibrium about the third month, according to the same table.

The relative infrequency of hypofixation in the cases of hyperdescent has shown that this latter condition is probably an overgrowth of the colon. However, the frequency of hyperdescent in the 105 necropsies is 21 per cent. and in the instances of hypofixation it is 36 per cent. (Fig. 8). This represents a very definite increase which may mean either that the intestine, because of its loose attachment, has slid down into the pelvis, which seems improbable from the previous argument, or that the process of fixation,

which has been completed early, may exert a restraining influence upon the further descent of the colon.

The relative increase or decrease in frequency of the membranes of hyperfixation in these cases with a mesentery of the ascending colon, as compared with the frequency in the entire series, is shown in Fig. 8. It may be noted by reference to this that membranes about the gall-bladder (cystocolic membranes) are relatively infrequent, as are also membranes and bands about the cæcum, appendix and ileum. On the contrary, those about the hepatic flexure and ascending colon are relatively increased. As will be shown later, these membranes are in large part the result of incomplete involution of the colic omentum of Haller and so represent incomplete development in the same sense as does hypofixation. Hence such a correlation between the two might be expected.

Hypofixation, in itself, caused angulation or kinking of the gut but once. In this instance the lower end of the colon was turned upward anteriorly and to the left, so that the tip came to lie in the region of the umbilicus, thus producing a sharp angulation on itself.

(b) *Hyperfixation*.—Normally the ascending colon, with the exception of two or three inches proximal to the cæcum, is attached to the areolar tissue in the flank and over the kidney, but at certain points the lines of peritoneal attachment may be accentuated. Thus at the lower end are found the parietocolic and mesentericocolic folds, improperly called the Jonnesco's ligaments; at the hepatic flexure, the right renocolic ligament of Haller; and at the transverse portion of the colon the "cystocolic fold" or ligament of Huschke. These folds are many times absent, and, indeed, it is difficult to establish a normal standard for any of these structures, but in as far as it is possible this will be attempted under the separate heading given below.

The subdivisions adopted in this discussion do not imply that the structures described are but modifications of the anatomical structures normally found in these positions, but are used as convenient topographical divisions of the membranes about this portion of the large intestine.

1. Cystocolic hyperfixation.
2. Hepatic flexure hyperfixation.
3. Pericolic hyperfixation.
4. Pericæcal hyperfixation.
5. Periappendicular hyperfixation.
6. Peri-ileal hyperfixation.

1. *Cystocolic Hyperfixation*.—The lesser omentum is described as extending from "between the transverse fissure of the liver on the right side of the abdominal portion of the œsophagus to the lesser curvature of the stomach and the upper portion of the anterior surface of the duodenum" (Piersol<sup>102</sup>). The portion included between the liver, the œsophagus and the stomach is called the "hepatogastric ligament," and that between the liver and the duodenum the "hepatoduodenal ligament." The free portion of the omentum ends above with the passing of the upper attachment out

upon the posterior surface of the gall-bladder, and below with its continuation over the descending portion of the duodenum as far as the transverse colon. This, then, comprises the hepatocolic ligament or cystocolic fold to which adequate attention was first attracted by Huschke, and which is sometimes termed the ligament of Huschke.

The cystocolic fold has been discussed by several writers, and the following table gives the frequency of occurrence as so determined:

Name	No. examined	Per cent.
Jonnesco <sup>22</sup> .....	100	25
Addison <sup>21</sup> .....	40	30
Mollison and Cameron <sup>108</sup> .....	50	20
Buy <sup>109</sup> .....	..	25
Bricon <sup>110</sup> .....	89	15
Reid <sup>84</sup> .....	20	30
Leveuf <sup>86</sup> .....	50	28
Ssulow <sup>111</sup> .....	145	23
Harvey .....	105	18

Six of Mollison's and Cameron's cases were in fœtuses and seventeen under five years of age, Reid's cases were all in fœtuses, and Leveuf's in infants autopsied directly or shortly after birth. Brewer <sup>112</sup> in addition reports 3 per cent. of 100 cases in which the cystocolic fold extended over the fundus of the gall-bladder. Ancel and Sencert, <sup>113</sup> as well as Rubin, <sup>114</sup> have in recent years noted this condition in the new-born.

In the present series only those cases were recorded as hyperfixation in which the fold extended upon the gall-bladder over a third of the length of this viscus, this being used as a convenient measure of its overdevelopment. In the 105 cases autopsied, 20 instances were noted falling within this definition, or about 18 per cent. (Fig. 5). These varied from simple folds, extending upon the gall-bladder an inordinate distance, to peritoneal bands and membranes spreading entirely over the fundus and outward upon the surface of the liver, with exactly the appearance seen several times during laparotomies in the adult and interpreted by the operator as indicative of chronic inflammation of the gall-bladder. In such instances the gall-bladder and intestine may be almost approximated by this hyperfixation, which may also serve to angulate the duodenum or transverse colon or both, producing on röntgen study the appearance of stasis and thus simulating duodenal ulcer (Harris <sup>132</sup> and Homans <sup>133</sup>).

Of these 20 variations, 12 were in males and 8 in females, or 25 per cent. and 15 per cent. respectively. As may be noted by reference to Fig. 6, this slight preponderance of the male in variations of hyperfixation holds true throughout except for ileal hyperfixation. The correlation of this with a like preponderance in hypodescent suggests that this represents an earlier maturity of the male.

The development of the cystocolic fold apparently reaches a stable condition sometime previous to birth, the three arbitrary periods shown in



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Fig. 7 having nearly the same percentage of incidence. Consequently one would not expect any correlation between the occurrence of this fold and the other variations which are to a great extent in a period of transition at the time of birth.

Reference to Fig. 10 shows the relative frequency of occurrence of the cystocolic fold in the entire series of cases and in the different variations under discussion. It will be noted that there are no definite differences,

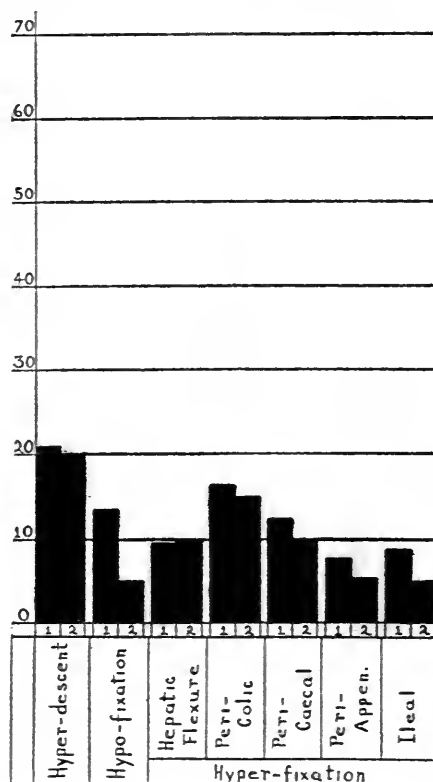


FIG. 10.—Incidence of peritoneal variations in the entire series (1) and in cystocolic hyperfixation (2) compared by percentage.

with the exception of that shown under the heading of hypofixation, where the cystocolic fold is, of course, present relatively infrequently.

There was no case observed in which the overgrowth of this structure led to kinking or serious angulation of the gut, although the possibility of this on further increase in size of the intestine was apparent. It seems very probable that such hyperfixation may at times produce stasis within the gall-bladder, but this point was not determined.

2. *Hepatic Flexure Hyperfixation.*—Fixation of the colon in the neighborhood of the right kidney is so closely correlated with the development of the great omentum that it is necessary to consider the embryonic status

of the latter. As Toldt,<sup>5</sup> Prenant,<sup>100</sup> and Leveuf<sup>96</sup> have pointed out, the omentum at about the sixth month of foetal life in man and also in the other primates may extend as far downward as the cæcum. In man it diminishes in extent as the foetus matures until it reaches only as far as the hepatic flexure, but in the higher monkeys it persists in its foetal condition.

One may consider, then, the normal extent of the omentum on the right as reaching as far as the hepatic flexure. It becomes there continuous by its

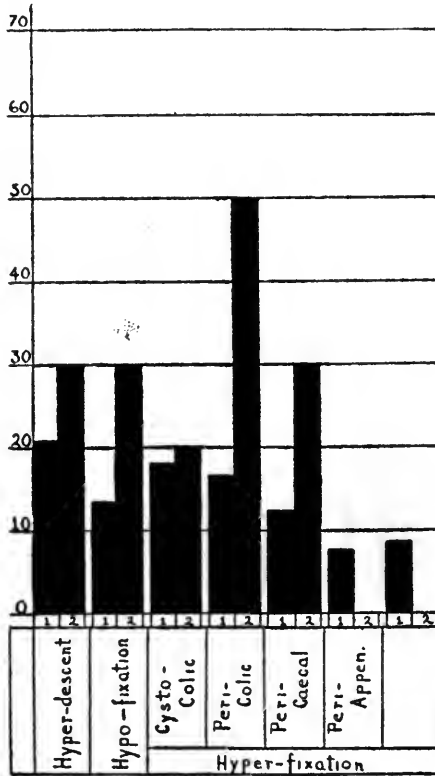


FIG. 11.—Incidence of peritoneal variations in the entire series (1) and in hepatic flexure hyperfixation (2) compared by percentage.

anterior layer with the peritoneum over the duodenum and the upper pole of the right kidney. A similar process on the left serves to form the ligamentum pleurico-colicum and in certain instances the adhesions and bands about the splenic flexure to which Payr<sup>41</sup> has called attention. If the process of fusion proceeds farther than usual, the omentum may be directly continuous with the parietal wall, and where persistent over the ascending colon may also be continuous with the parietal peritoneum, as Leveuf<sup>96</sup> has pointed out, producing pericolic hyperfixation. Also the persistence of the colic omentum of Haller may result, by a failure on its part to grow as rapidly as the colon itself, in a relative shortening of the omentum as it stretches

across the colon, producing angulation and kinking in the latter or at least producing bands and membranes having quite the appearance which we have come to associate with peritoneal inflammation. In a third variety the omentum stretches across the angle of the junction of the ascending and transverse coli and in exaggerated instances forms the so-called "double-barrelled" colon.

In the examination of 50 infants at or shortly after birth Leveuf<sup>96</sup> found 10, or 38 per cent., with a prolongation of the omentum upon the ascending coli beyond what he considered normal for the adult. It is his opinion that the persistence of this structure accounts for the so-called "Jackson's veil."

In the instances under discussion hepatic hyperfixation includes omenti which descended more than 2 cm. upon the ascending colon as well as other membranes and band-like structures in this region. Using this standard in 105 cases, Haller's omentum was present nine times and membranes about the hepatic flexure, probably of this origin, once, giving a total of ten omental membranes, or of 9.5 per cent. (Fig. 5.) These structures are slightly more prevalent in the male (Fig. 6), being associated with cystocolic hyperfixation in this respect. There is a slight increase as the infant grows older (Fig. 7), and in this it is correlated with a similar increase in the pericolic hyperfixation.

An inspection of Fig. 11 shows the quite marked association of this variation with hyperdescent and still more strikingly with hypofixation. It was suggested previously that hyperdescent may be due in part to a lack of normal fixation with its restraining effect on the growth of the intestine. The correlation between the persistence of the foetal type of colic omentum and hyperdescent would seem to confirm this. Hypofixation and the colic omentum naturally go hand in hand inasmuch as both are deficiencies of development.

A further inspection of this table shows that about 50 per cent. of these persisting omenta occur in conjunction with pericolic hyperfixation and 30 per cent. with pericæcal hyperfixation. This serves to support Leveuf's view that adhesions about the colon and cæcum are the result of the persistence of the foetal type of omentum in a large number of cases, but, on the other hand, quite as clearly demonstrates that this hypothesis does not cover all instances of such adhesions. The other factors responsible will be discussed under the appropriate headings.

It is also of interest to note that none of these omental membranes are associated with periappendiceal or ileal hyperfixation, which should serve to discourage the extension of Leveuf's hypothesis to this portion of the intestine.

In two instances the presence of the colic omentum caused definite angulation or kinking of the large intestine.

3. *Pericolic Hyperfixation*.—The colon on the right side in adult life is usually attached over the upper two-thirds of the ascending portion and

over about one-third of its circumference to the areolar tissue over the posterior abdominal wall and the right kidney, the lower third merging with the cæcum and, like it, being covered with peritoneum. As the peritoneum leaves the colon on its posterior surface and turns downward toward the pelvis it is reflected laterally in two folds, the parietocolic and the mesentericocolic.

The colon continues to increase in length up to the third month after birth, while the process of fixation is going on over the same time, but lasting somewhat longer; that is, up to the sixth or seventh month after birth. There is then obviously a certain relationship between these two processes, which is essential to the normal fixation and descent of the gut. Certain aberrations in this relationship have been suggested as the cause of "Jackson's veil" (pericolic hyperfixation). C. H. Mayo<sup>79</sup> states that the colon prematurely fixed continues to grow and thus appears to burrow under the peritoneum, dragging it downward in the slanting membranous folds seen in this condition. Flint<sup>81</sup> suggests that such membranes represent successive secondary fusing of the parietal, colic and omental peritoneum which have been drawn downward by the continued descent of the cæcum. Leveuf,<sup>80</sup> as noted previously, refers these bands and membranes to a persisting and adherent colic omentum. Many writers, and especially Riedel and Lane, have called attention to the thickening of the mesentery of an unattached colon so that it seems to be made up of several suspensory bands.

The term pericolic hyperfixation may then refer to and include several different variations, all of which, however, come under the definition of a fusing together of peritoneal surfaces normally separate. The structures in this series varied from film-like prolongations of the peritoneum, scarcely to be observed until the intestine was distended, to distinctly thickened and strong bands of peritoneum causing acute angulation of the gut. In some instances these were very apparently remnants of the foetal colic omentum, in others these were portions of the parietal peritoneum which had become adherent over some small area to a greater extent than elsewhere, or over the greater length of the ascending colon so that when the latter became distended the peritoneum was stretched out in the form of a membrane. In still others a premature fixation with continued growth of the intestine had produced much the same effect, and here the membrane might be drawn into folds like those in a drooping pennant or the colon held as if in a "diaphanous bag" (Jackson<sup>86</sup>).

Though one recognizes in the description of Virchow<sup>14</sup> and many others of the early writers the characteristics of the membranes about the ascending colon, there is but little data at hand as to their frequency. Morley<sup>90</sup> examined 36 fetuses and found a "Jackson's membrane" in 4, while Eastman<sup>77</sup> in 28 found in 5 the same structure, which he termed the parietocolic fold. Cheever<sup>88</sup> in 30 stillborn infants found this form of hyperfixation 4 times, but Eisendrath and Schnoor<sup>95</sup> state that in 10 fetuses each showed some form of what Eastman terms the parietocolic membrane. Blake<sup>118</sup>

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has even gone so far as to state that Jackson's membrane is a perfectly normal structure always present.

In the series of 105 infants here reported, pericolic hyperfixation was observed some 17 times, or in something over 16 per cent. (Fig. 5).

It occurred with about the same frequency in both sexes (Fig. 6).

According to the three arbitrary age periods previously described, there is a quite marked increase in frequency during the first year of life; namely from about 9 per cent. during the first two months to about 25 per cent.

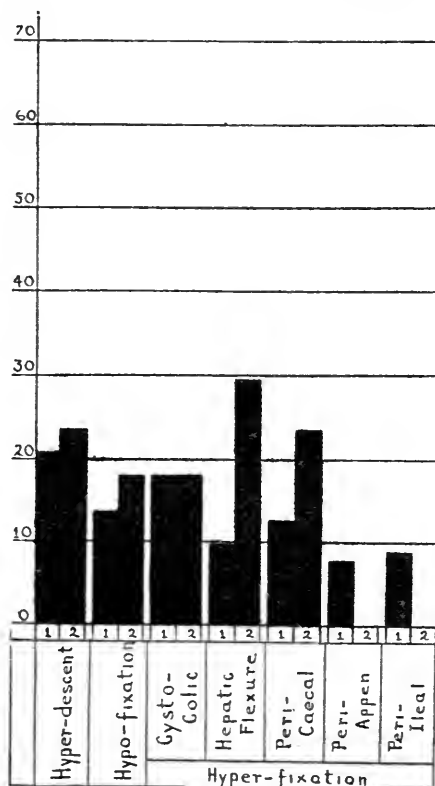


FIG. 12.—Incidence of peritoneal variations in the entire series (1) and in pericolic hyperfixation (2) compared by percentage.

after seven months of age (Fig. 7). This illustrates again the relative tardiness of completion of descent and fixation and might be taken as evidence for the theory of inflammatory origin were it not, as will be shown later, that the pericaecal, periappendicular and peri-ileal hyperfixation decreases over this same period. It also shows rather conclusively that only a minority, at most, of these pericolic membranes can be persisting colic omentum of Haller, inasmuch as the tendency in the latter is toward retrogression.

An inspection of Fig. 12, indicating the relative frequency of occurrence of the various variations under discussion in the entire series and in the

cases of pericolic hyperfixation, shows the following: Hypofixation is present in about 4 per cent. more of these cases, a difference hardly above the limit of error. There is no greater frequency of hyperdescent or of the cystocolic folds. Membranes about the hepatic flexure, however, are present about three times as frequently in association with this group as in the complete list, and pericæcal hyperfixation twice as frequently. This group, then, stands closely related to the lesions on either side, a greater number, however, being of the same derivation as the omental. As in the preceding group of hyperfixation about the hepatic flexure, there is no association whatever with the membranes about the appendix and the ileum, suggesting that the latter have a somewhat different derivation than any so far discussed.

Pericolic membranes produced angulation or kinking of the gut twice in the 17 instances where such structures were present.

4. *Pericæcal Hyperfixation*.—The relations of the cæcum to the peritoneum as described by various authors are most confusing, inasmuch as they frequently disagree not only in content, but also in nomenclature.

The cæcum is invested on all sides by peritoneum and in the great majority of instances, all but 6 per cent. according to Berry,<sup>25</sup> there is no mesentery. Occasionally, however, it is directly attached to the posterior wall or has a mesentery directly continuous with the mesocolon. In the typical specimen examined *in situ*, turning the cæcum upward reveals certain peritoneal folds and fossæ, which, according to Berry, may be named from the right to the left as follows:

External-parieto-colic fold.

Internal-parieto-colic fold.

Mesenterico-parietal fold.

These are the structures frequently spoken of as the folds or ligaments of Jonnesco, the credit for the description of which should, however, be distributed between Huschke and Treitz. It is only fair to Jonnesco to state that he assigns this credit where it properly belongs.

The extreme variability to which these structures are subject and of which the uncertainty of our knowledge is a measure, renders it somewhat questionable as to whether they are worthy of the dignity of as extensive a nomenclature as has been assigned them. For the purpose of simplicity they will be spoken of in this paper as the subcæcal folds.

It has been assumed by some that the purpose of these folds is to serve as guys to anchor the cæcum or rather the lower end of the colon in place, and that they undergo a very purposeful anatomical development. Treitz,<sup>16</sup> Gruber,<sup>20</sup> and more recently Lockwood and Rolleston<sup>29</sup> state that the cæcum is dragged downward by the gubernaculum through the medium of the mesorchium or mesovarium, the peritoneum following unequally, thus producing the folds and fossæ. Waldeyer<sup>19</sup> rejected this theory and suggested that the development of the cæcum after fixation of the colon was responsible for such plication of the peritoneum. Jonnesco,<sup>22</sup> and more

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recently Berry,<sup>25</sup> thought that the delayed and secondary fixation of the ascending colon as described by Toldt<sup>5</sup> would more reasonably account for such folds. These theories are especially interesting as unrecognized progenitors of hypotheses advanced very recently in respect to the formation of Jackson's membrane, Lane's band, etc.

In the examination of the subjects reported in this paper these subcæcal folds were regarded as normal structures and, consequently, were not recorded, although possibly having the same derivation as the pericæcal mem-

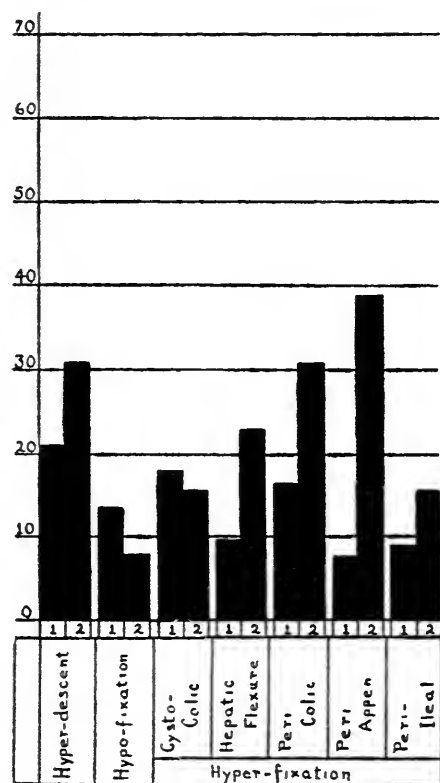


FIG. 13.—Incidence of peritoneal variations in the entire series (1) and in pericæcal hyperfixation (2) compared by percentage.

branes. The latter were in general of two types, those extending from the parietal wall to the cæcum and those extending only over the surface of the cæcum. Both were frequently continuous with membranes of a similar nature covering the colon. In the former the peritoneum frequently extended in a fan-shaped manner from the parietes downward over the cæcum, in exaggerated instances giving the appearance of a sling. At other times a definite fold was produced which could easily be imagined as serving a suspensory function. Lastly and rarely the cæcum itself was partially attached to the parietal wall by a mesentery. In the case of the membranes

confined to the cæcum itself the appearance was that seen in the omental membranes above, where the embryonic omentum had not undergone involution, and fine bands and thinly spread peritoneum stretched across furrows in the gut.

Such membranes were present in 13 of the 105 cases examined, being very slightly more prevalent in the male (Figs. 5 and 6).

They were much more frequent in the first of the arbitrary age periods (Fig. 12), corresponding in this respect with the periappendicular and perileal hyperfixation, suggesting, as will be discussed later, that the membranes about the cæcum and ileum tend to decrease in frequency with the increase in age, the converse of the condition about the hepatic flexure.

Pericæcal hyperfixation is associated with hyperdescent, much more frequently than with hypofixation (Fig. 13). It is also coincident with many pericolic and hepatic membranes but much more so with periappendicular hyperfixation, suggesting that only a relatively small number of pericæcal membranes are a result of deficient involution of the omentum. Six or nearly one-half of these produced some kinking or angulation of the cæcum, but for the most part this consisted of an increase, very distinct, however, in the depth of the normal furrowing, and represented an exaggeration of the normal folding of the cæcum as described by Toldt.

5. *Periappendicular Hyperfixation*.—In close relation to the appendix there are normally three quite distinct peritoneal folds which are named, according to Berry's<sup>25</sup> classification, from above downward as follows:

The ileocolic fold.

The ileocæcal fold.

The meso-appendix.

The ileocolic fold was first described by Luschka<sup>17</sup> and more in detail at a later date by Jonnesco,<sup>22</sup> who defined it as " . . . un repli péritonéal qui part du feuillet antérieur ou droit du mésentère, passe pardessus ou en avant de la portion terminale de l'iléon pour se perdre sur le cæcum."

The ileocæcal fold or, as more commonly called in the English literature, the "bloodless fold of Treves," occupies the ileocæcal angle in front of the mesoappendix with three of its borders attached, extending from the ileum downward upon the cæcum.

It is very difficult to gain from the literature a definite idea of the frequency of the variations in the meso-appendix; Berry<sup>25</sup> states that it may be termed normal in about 75 per cent., but these as well as Treves' figures are based upon variations in the position of the meso-appendix rather than upon variations in which it assumes the appearance of an adhesion. In Treves' sixth position he states that "the appendix has no mesentery at all, but is adherent in a vertical line to the posterior wall of the cæcum, its extremity being, as a rule, however, free." In this position Berry found 3 per cent. of the cases examined by him. He states, further, that "if the writer's views as to the etiology of appendicitis be accepted, it follows that about 6 per cent. of the populace have appendices so situated as to predispose them



to appendicitis." Ferguson<sup>116</sup> in his 200 cases found in 77 the appendix so placed and covered by peritoneum that its perforation would open into the subperitoneal tissue. Lockwood and Rolleston<sup>29</sup> in 160 examinations found the appendix adherent in 33. Mollison and Cameron<sup>108</sup> describe, in an investigation of 35 autopsies, adhesions about the appendix, in three of which there was no evidence of peritoneal inflammation. Leveuf<sup>96</sup> examined some 50 fetuses and in 16 per cent. of these found peri-appendicular adhesions. Albrecht<sup>117</sup> in 500 children, the oldest being 6 years of age, found 15 per cent. with anomalous positions produced by adhesions. Many other writers have called attention to the presence of congenital adhesions about the appendix, but extensive data as to the frequency of such abnormalities are not at hand.

Only the extreme instances of unusual attachment of the appendix were noted in this series, and these would for the most part fall in the very late variations of the meso-appendix as classified by Treves. The most striking form was where the appendix was held posterior to the cæcum in the retro-colic fossa by an adhesion sometimes near the base but frequently extending nearly to the tip, which was usually free. The appendix gave the appearance of having been relatively prematurely fixed and with the descent of the cæcum of being turned upward and backward upon itself. In all, 8 instances (Fig. 5) of hyperfixation were observed in this series of 105 cases and (Fig. 6) these were distributed evenly between the male and the female.

The incidence according to the arbitrary age periods (Fig. 7) is about the same in the second and the first periods but nil in the third. This suggests that there may be a certain amount of involution involved in the formation of the peritoneal attachments of the appendix, somewhat analogous to that observed in the development of the colic omentum of Haller, but the number of cases observed is too few to arrive at any definite conclusion on this point.

Such periappendicular hyperfixation is more frequently associated with pericæcal and peri-ileal hyperfixation (Fig. 14) and not at all with that observed about the colon and hepatic flexure, indicating that the latter are not of an analogous derivation.

Kinking of the appendix in connection with these variations was observed twice.

**6. Peri-ileal Hyperfixation.**—The ileum is normally free throughout, having the shortest portion of its mesentery at the ileocæcal junction. Usually the ventral layer of the mesentery is continuous to the right with the peritoneum covering the anterior surface of the ascending colon and cæcum while the dorsal layer turns backward and to the left to cover the posterior parietal wall. At the junction of the cæcum and the ileum this posterior layer forms a fold leading downward toward the iliac fossa, the mesentericoparietal fold of Jonnesco and Berry, first described by Huschke<sup>12</sup> and discussed above under the heading of Pericæcal Hyperfixation. This should not be confused with the structure now known as Lane's band.

Normally, as stated previously, the ventral sheet of the mesentery of the ileum does not fuse with the posterior parietal peritoneum, but, as was pointed out by Toldt,<sup>5</sup> writing in 1879, this occasionally occurs so that the terminal ileum is fixed to the posterior parietal wall in the same manner as the ascending colon. Treves<sup>21</sup> wrote in 1885 that "in not a few specimens the terminal part of the small intestine has been closely attached to the psoas muscle, not by direct adhesion, but by means of a fold of peritoneum that has passed from the or under the layer of the mesentery to the serous

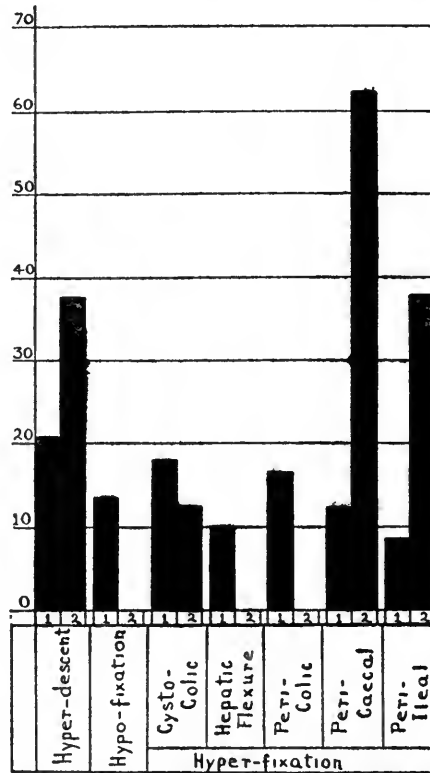


FIG. 14.—Incidence of peritoneal variations in the entire series (1) and in periappendicular hyperfixation (2) compared by percentage.

membrane covering that muscle." Addison,<sup>31</sup> in 1900, described such conditions in detail and distinctly called attention to the presence of adhesions at this point which have since become known as Lane's bands. To quote Addison: "This portion of the lower end of the ileum is often made firmer by a prominent peritoneal fold passing downwards from beneath the ileum, near where it overlies the inner border of the psoas, to Poupart's ligament. . . . With a shorter peritoneum the movements of this part of the ileum become more limited. Sometimes it is bound down completely to the iliac fossa, while in other cases it lies in the pelvic cavity with a prolapsed cæcum."

## PERITONEAL RELATIONS OF ASCENDING COLON

Recently Reid<sup>84</sup> has described this condition anew, associating with it, as did Addison, a vestigial fold resulting from the descent of the ovary or testicle, and has given it the name of the genito-mesenteric fold. This association is far from original, being first proposed by Treitz,<sup>18</sup> in 1857, who supposed that the mesenterico-parietal fold was formed by a union of the mesorchium with the serous coat of the cæcum and that the descent of the orchis drew out the peritoneum into a fold which he named the "plica genito-enterica." This theory was rejected by Waldeyer<sup>19</sup> and Jonnesco,<sup>22</sup> the latter basing his opinion on not finding any such association embryonically, and on Toldt's<sup>5</sup> researches which showed the secondary fusion of the colon at a late period in foetal life.

The presence of a vestigial fold, in many cases, in the peritoneum lining the posterior parietal wall in this particular region can not be doubted, and such a genital fold has long been recognized by anatomists, being constantly seen in the young embryo.

The Wolffian body, or mesonephros, is enclosed and attached to the posterior body wall by a fold, the mesonephridium, of which the upper elongated end is continued to the diaphragm (plica phrenico-mesonephrica) and the lower to the abdominal wall in the inguinal region (plica inguino-mesonephrica). A band of muscular tissue appears in the latter, extending from the genital portion of the mesonephros to the anterior abdominal wall in the region of the future inguinal ring. This ultimately becomes the gubernaculum testis in the male and the round ligament in the female. The testicle and similarly the ovary, having been differentiated from the mesonephros, begin their descent from the region of the second upper lumbar vertebra during the second month of foetal life and reach the abdominal wall toward the end of the third month, where they remain until shortly before birth. It is obvious, then, as Jonnesco reasoned, that this descent cannot affect the cæcum and much less the ileum which at this time of foetal life are still undescended. The upper part of the mesonephridium does, however, in certain instances remain as a fold running from the inguinal canal in the male or the broad ligament in the female upward over the iliac fascia and psoas muscle until it meets the mesentery of the ileum and so disappears from view. If the latter chances to be fused with the posterior peritoneum this fold runs directly to the point of fusion, giving the impression that it has something to do with this abnormal condition, which, as one can see from above, is not true.

Accurate statistics as to the incidence of hyperfixation of the ileum are difficult to find. Addison<sup>81</sup> in 40 cases described the ileum as firmly fixed in the iliac fossa in 8, or in 20 per cent. Mollison and Cameron<sup>108</sup> report a similar condition in 5 of 50 cases, or in 10 per cent. In 55 per cent. of Reid's<sup>84</sup> cases a "genito-mesenteric fold" was present, but this merely serves to show the frequency of persistence of the plica mesonephrica and does not give any information as to the incidence of ileal hyperfixation. Gray and Anderson<sup>83</sup> report 10 per cent. of the cases examined by them as

having a Lane's band. Leveuf<sup>96</sup> records its presence in 10 per cent. of the foetuses which he investigated; Alglave<sup>104</sup> states that in 100 necropsies he found ileal fixation with a free cæcum in 13 per cent., with a fixed cæcum in 8 per cent. Kelly and Hurdon<sup>118</sup> also called attention to such fixation of the ileum.

In the autopsy examinations here reported only those incidences were noted in which the hyperfixation of the ileum was sufficient to render the terminal three inches relatively immobile. The mesentery was much more

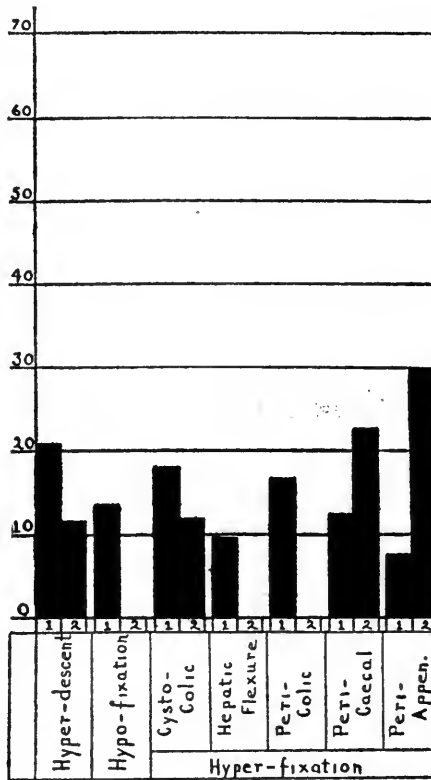


FIG. 15.—Incidence of peritoneal variations in the entire series (1) and in peri-ileal hyperfixation (2) compared by percentage.

frequently fused with the posterior parietal peritoneum for a considerable distance, but inasmuch as these did not correspond to the description of Lane they were not noted. In all, 9 instances were observed, or 8.6 per cent. of the number of infants examined (Fig. 5). Some of these were associated with the vestigial fold previously discussed, but the latter was not of necessity present.

Hyperfixation was found three times as frequently in the female as in the male (Fig. 6).

The rapid decrease in the incidence of this variation in the first year of

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life as suggested by Fig. 7 is not readily explicable, but may be due to the small number of necropsies. It is apparent from the observations of other workers, whose statistics are quoted above, that this fold does persist into adult life with much the same frequency as in those infants up to two months of age.

A marked association of this abnormality with periappendicular and pericæcal hyperfixation is shown by Fig. 15, emphasizing again that these membranes are not, as Leveuf suggested, a result of a deficient involution of the omentum.

Kinking of the ileum in association with hyperfixation was observed only once.

### IX. DISCUSSION

In the presentation of the data above it has been assumed that these membranes and bands found in infants during the first year of life are developmental in origin and not the result of a peritonitis. In order to assure oneself of this it is necessary to consider the following points.

Prenatal peritonitis is of itself a rare condition, only sixty cases having been reported up to 1908 (Helbing<sup>119</sup>), of which 25 were described by James Y. Simpson in 1838. There are in general two types, the one due to syphilis (Silbermann<sup>120</sup>) and the other to congenital atresia or open diverticuli with an aseptic peritonitis as a result. The picture in both of these forms is that of a chronic generalized peritonitis with adhesions scattered throughout the abdomen.

Any form of bacterial peritonitis in the foetus is of necessity metastatic in origin and consequently of even greater rarity than a similarly caused lesion in the adult.

Postnatal peritonitis as a causative factor must, of course, be limited to those forms incidental to the first year of life. By far the most frequent is that following infection of the cord which leads to localized inflammation in the region of the umbilicus, multiple abscesses in the liver, or generalized peritonitis. Such infections are overwhelming in their virulence and certainly show no tendency to localization about the colon and cæcum.

To explain such abnormalities on the basis of a syphilitic infection requires the highly improbable assumption that something over 50 per cent. of the infants coming to autopsy in this hospital not only had syphilis, but also had a syphilitic peritonitis. (Fig. 5, column 10.) Tuberculosis requires a similar assumption.

A low-grade chronic infection such as is postulated in the hypothesis of "perienteritis membranosa" (Gerster) does not explain adequately the many membranes and bands present during the first two months of postnatal life, since such a chronic condition has hardly had time to establish itself, nor would this explain the *decrease* in the frequency of occurrence of those about the cæcum, appendix and terminal ileum as the infant grows older (Fig. 7). One would have to assume a different origin for this group

at least, which has exactly the same general characteristics as those seen higher up on the colon.

Inasmuch as the contents of the intestines are sterile until birth a pericollitis as a result of infection from the intestine previous to this event is of course impossible, and yet Flint,<sup>81</sup> Leveuf,<sup>86</sup> and others have clearly demonstrated that membranes and bands of the type under discussion are frequently found in the foetus.

Finally, thirteen different specimens showing the most marked membranes were examined for histological evidence of inflammation of the peritoneum or its adjacent structures. Even in instances of ulcerative follicular colitis the cellular infiltration was not found to extend beyond the muscle wall of the gut. It can be stated very positively that there was no histological evidence of inflammation of the peritoneum in these cases. The following description is typical of the picture seen in these sections (Figs. 16 and 17.

Section evidently taken at right angles to the long axis of two contiguous portions of the large intestine. Stretching across the angle between these may be seen on the serosal side a band of rarefied tissue.

Under magnification the mucosa shows the normal structure of that of the large intestine. The most superficial epithelium is in places eroded, apparently the effect of postmortem changes. The glands of Lieberkühn are distended with mucus, but there is very little cellular detritus and no indication of ulceration or hemorrhage. Elsewhere there is no increase or change from the normal in the cells found in the mucosa. The vessels of the submucosa are not distended nor is there any evidence of diapedesis. The solitary lymph nodules are not unusually prominent. The muscular coats show no cellular infiltration and are in no wise abnormal. The band of tissue noted above is now seen to be made up for the most part of a very loose network of fibro-elastic tissue, covered externally by a layer of endothelial cells. In this tissue there are occasional capillaries surrounded by a few plasma cells, and not frequently one of the latter is seen at some distance amidst the fibrous strands. The normal number of fibroblasts are distributed throughout this layer. There is nowhere any suggestion of cellular infiltration or indication of an acute or chronic inflammatory reaction. The endothelial covering does not seem thicker than is normal and mitoses are not apparent.

It scarcely needs argument, once having shown the inadequacy of the inflammatory theory, to convince one of their developmental origin. Their localization at the points on the intestine where certain anatomical variations, long recognized as such, are especially prone to occur, their extreme mutability during the first year of life, their correlation with the descent and fixation of the colon and with the retrogression of the colic omentum, all point to what one might expect from such late simultaneous development, namely, the frequent formation of variations of the peritoneal attachments of the right colon, cæcum, appendix and terminal ileum.

This being true, it remains to be shown that the adhesions seen in the adult in this region of the abdomen are of the same character. It is necessary first to exclude from this consideration those adhesions which show a very

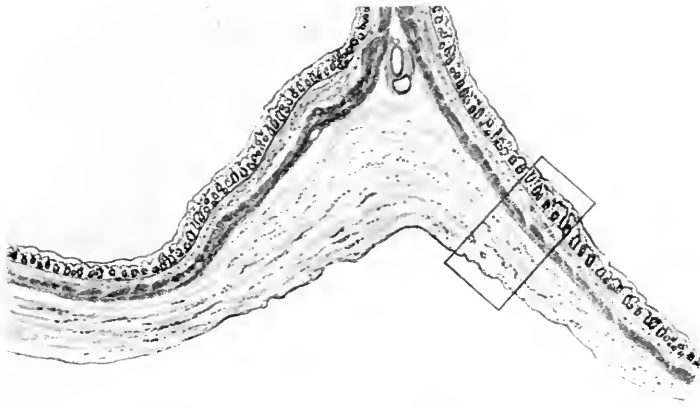


FIG. 16.—Section of peritoneal membrane from specimen of hepatic flexure hyperfixation (see Fig. 20), necropsy No. 99 (magnified  $\times 10$ ). Sections from tissue hardened in Zenker's fluid and stained with Delafield's hæmatoxylin and eosin and Van Gieson's connective-tissue stain. Note absence of inflammatory reaction. Enclosed area enlarged in Fig. 17.

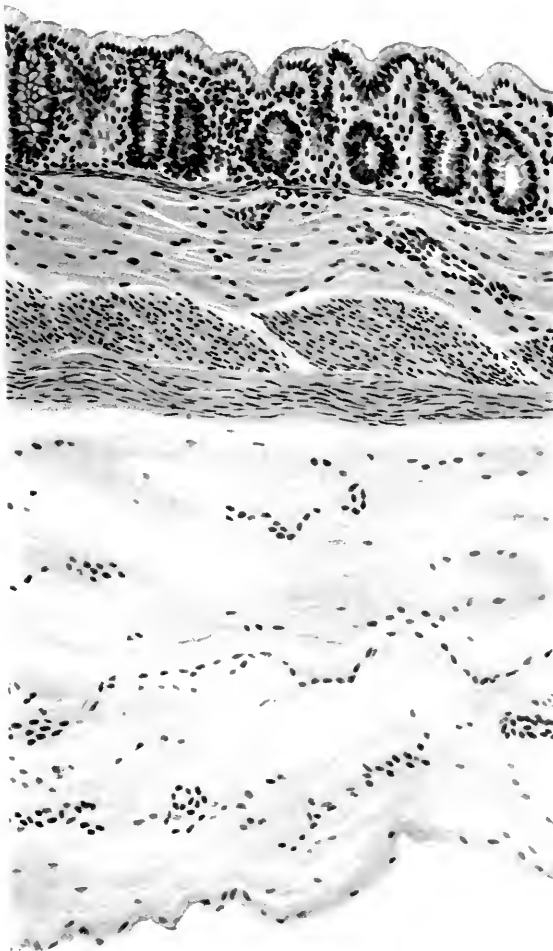


FIG. 17.—Section of peritoneal membrane shown in Fig. 16. Note absence of inflammatory reaction.

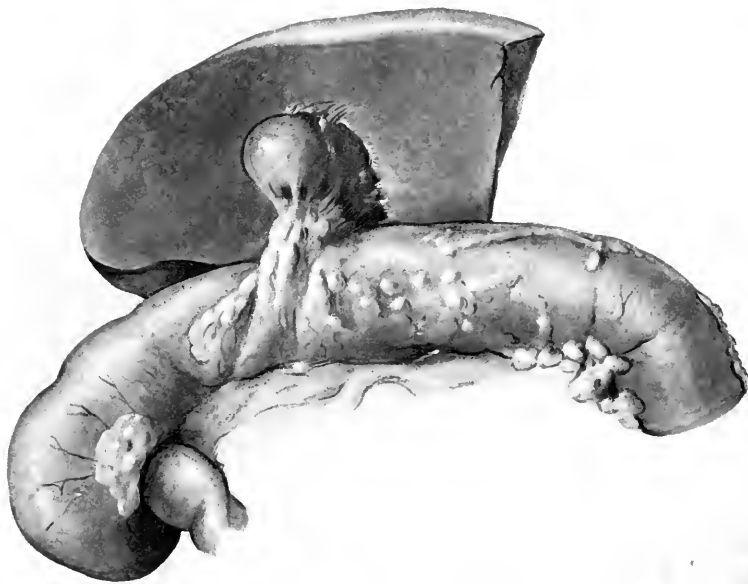


FIG. 18.—Specimen of cystocolic hyperfixation from necropsy No. 316. Note extension of cystocolic membrane upon gall-bladder and colon, also presence of fat in the band.

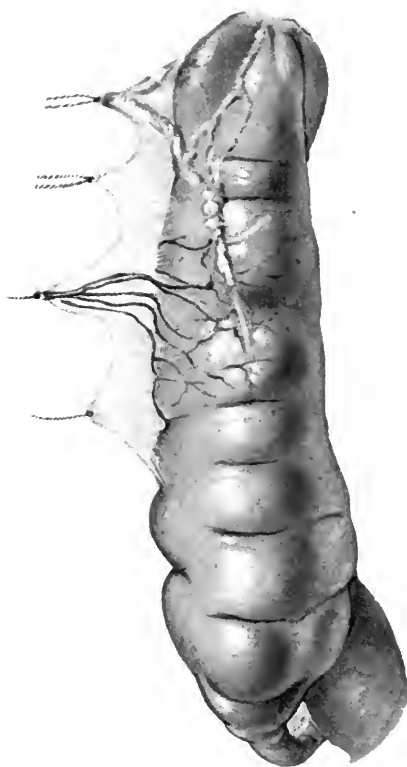


FIG. 19.—Specimen of hepatic hyperfixation from necropsy No. 281. Note extension of omentum downward upon colon and its immediate relation with the parietal peritoneum.





FIG. 20.—Specimen of hepatic flexure hyperfixation from necropsy No. 345. Note angulation of gut and distention of cæcum.



FIG. 21.—Specimen of pericolic hyperfixation from necropsy No. 361. Note extension over angle of gut and the junction with the parietal peritoneum.



FIG. 22.—Specimen of pericolic hyperfixation from necropsy No. 256. Portion of "veil" has been torn apart to show underlying gut.



FIG. 23.—Specimen of pericæcal hyperfixation from necropsy No. 241. Note the diaphanous character of the membrane and its extension over a furrow in the gut.

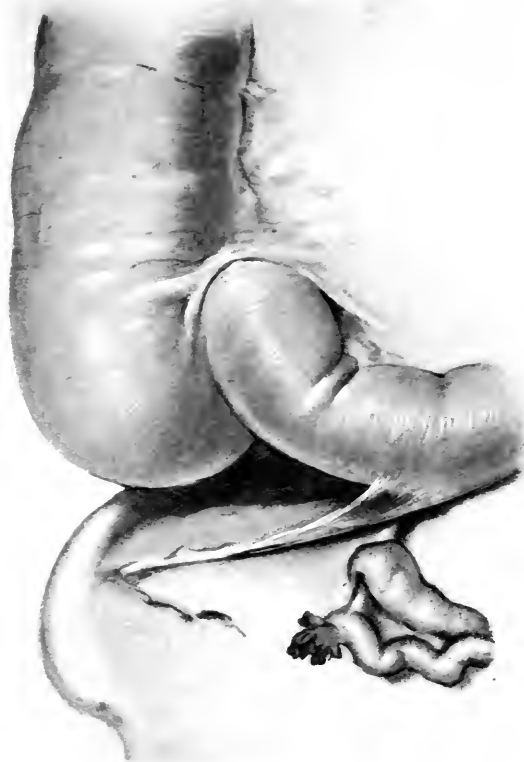


FIG. 24.—Specimen of peri-ileal hyperfixation from necropsy No. 223. Note that this band does not correspond with the plica genito-mesenterica shown behind the ovary.

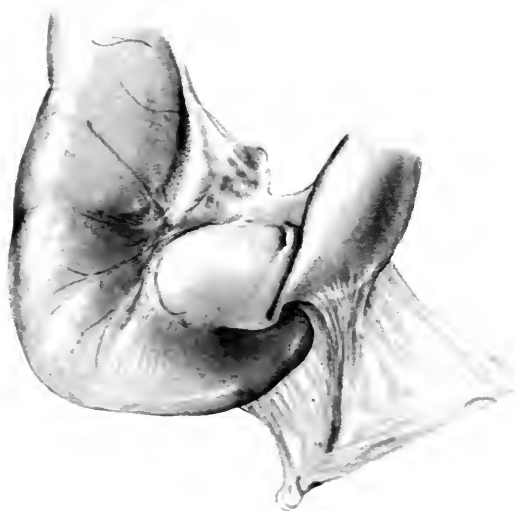


FIG. 25.—Specimen of peri-ileal hyperfixation from necropsy No. 266. This shows the angulation of the ileum that may be produced by this band.



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apparent inflammatory etiology; that is to say, definite macroscopic or microscopic changes in the tissues primarily involved in the inflammation; in other words, those cases in which a diagnosis of inflammation or injury could be made were adhesions not present. It is also necessary to exclude certain groups of idiopathic, chronic peritonitis in which the peritoneum is very apparently primarily at fault and which present very definite clinical and pathological pictures. Such are polyserosites and proliferative and chronic hemorrhagic peritonitis. There are left then the localized adhesions about the gall-bladder, duodenum, ascending and transverse colon, the cæcum, appendix and ileum, in which no definite anatomical evidence of inflammation is present, unless the adhesions themselves are taken to be such. Are these structures in the adult of the same nature as those seen in this series of autopsies and reported by others; that is to say, are they developmental variations?

The only method which could answer this question beyond any possible objection would be to observe by many autopsies the transition of these congenital membranes from infancy to adult life and observe at frequent intervals the incidence of inflammation in the surrounding structures. This unfortunately has not been done in detail, though the observations of Toldt<sup>5</sup> and Albrecht<sup>117</sup> covered this field fairly well and led them to believe such adhesions developmental. The argument for the present must rest almost entirely on four points; namely, the similarity of location, the similarity of appearance, the insufficiency of the evidence which accredits such "adhesions" in the adult to inflammation, and the marked dissimilarity of appearance of this type from those caused by inflammation.

It is unfortunately confusing that the regions in which these membranes are found in infants are also the most frequent sites of inflammation within the abdomen. It must be granted, however, that many, perhaps the majority, of such structures in the adult show no definite anatomical inflammatory basis; that is, there is no sign of inflammation in the adjacent viscera unless the adhesions themselves are taken to be such. With this in view the similar location in the infant and in the adult is corroborative proof of their identity.

The similarity in appearance is a fact which is difficult to convey except by the actual demonstration of specimens. Drawings and specimens are, as a rule, necessarily inaccurate and limited in their portrayal of peritoneal adhesions. However, the plates shown here (Figs. 16, 18, etc.), as well as the excellent drawings in the article by Flint<sup>81</sup> and in the monograph by Gray and Anderson,<sup>82</sup> can scarcely fail to convince one that there is a remarkable resemblance between these congenital membranes and bands and those seen in a similar location in adult life. In addition we have the testimony of many observers (Flint,<sup>81</sup> Gray,<sup>82</sup> Morley,<sup>90</sup> Moynihan,<sup>94</sup> Leveuf,<sup>96</sup> Eisen-drath and Schnoor,<sup>95</sup> etc.) as to the similarity, while there is, on the other hand, the one observer (Chapple<sup>121</sup>) stating that these structures in the adult and in the infant are dissimilar.

If it could be shown that any considerable number of the adhesions of the type under discussion seen at the operating table and at autopsy in the adult had a definite inflammatory basis, the persistence of the congenital membranes into adult life would be difficult to prove. It has been granted by most observers that the familiar acute types of peritonitis do not produce adhesions of this distribution and appearance, nor has it been suggested that the definite and well-recognized types of chronic, idiopathic inflammation mentioned above are in any wise responsible. Consequently it has been found necessary to propose and attempt to prove an hypothesis something as follows:

Fecal stagnation occurs as a result of ptosis or other mechanical obstruction (Virchow,<sup>14</sup> Gerster,<sup>59</sup> Eastman,<sup>77</sup> Wilms,<sup>59</sup> Klose,<sup>63</sup> etc.) or from loss of muscle tone of the bowel (Fischler<sup>62</sup>). The bacteria or their toxins from the dammed-back feces pass through the intestinal wall and incite a peritonitis. The statement of such an hypothesis is simple, the proof more difficult. It rests in the first place upon the assumption that bacteria and their toxins readily pass through the undamaged intestinal wall into the peritoneal cavity. There is no proof for such an assumption. It is true that *B. tuberculosis* (Ravenel<sup>122</sup>), *B. typhosi* and *B. coli* (Franke<sup>123</sup>), as well as many other bacteria, pass through the intestinal *mucosa* without evident damage to it and are then carried to the neighboring lymph glands. With chylous ascites it is conceivable that they might be washed back into the peritoneal cavity, but normally the tendency is entirely in the opposite direction. It has been shown in experimental herniæ in animals that infection of the hernial sac does not occur until there is very definite injury to the wall with interference with the circulation (von Brunn<sup>1</sup>).

It is conceivable that an organism might develop the faculty of passing directly through the wall, as has been suggested by Bassler.<sup>124</sup> None of the bacteriological criteria as applied to the isolation and identification of an organism responsible for a given disease have been filled in respect to the "*B. Membraformis*" described by this author.

It is also conceivable, as suggested by Adami,<sup>125</sup> that a condition of "subinfection" may be present; that is, that organisms of low virulence are constantly passing into the blood stream. In support of this is the work of Opie,<sup>126</sup> in which he has shown that the simultaneous injection of *B. Coli* and the giving of chloroform may produce cirrhosis of the liver in dogs. It is a far cry, however, to say that the cirrhosis seen in man is produced in a similar way. Moreover, these adhesions or even intestinal stasis itself are not correlated with such a cirrhosis.

The only attempt so far on record to prove experimentally that long-continued and severe stasis in the colon produces adhesions is that reported by Eastman.<sup>77</sup> Unfortunately, there is no detailed report of this work including protocols of experiments and controls, so it is difficult to discuss intelligently the findings. One knows, however, that in dogs, cats and rabbits, congenital variations in the peritoneal folds are exceedingly fre-

quent and indeed the normal attachments have many times the appearance of adhesions. It is obvious, then, that only the most painstaking control of such work will suffice. It should also be borne in mind that any experimental condition which produces an actual colitis with ulceration or other evidence of severe injury to the colon does not correspond with the conditions in man, inasmuch as the great majority of the cases, so far as recorded, show no anatomical evidence of inflammation of the colic wall. That this is true even when accurate studies are carried out, of which there is a singular dearth, is indicated by the report of Keith.<sup>97</sup> Even in such an extreme stasis as is present in Hirschsprung's disease it is not customary to find adhesions.

As suggested by Hofmeister,<sup>97</sup> one might say that such adhesions were the result of a previous acute attack of appendicitis, cholecystitis, or colitis. It is, of course, exceedingly difficult to rule out such factors, especially if one grants that the "anfallsfreie Appendicitis" of Klemm is capable of the production of adhesions. It is more probable, however, that the latter is in reality a result of the mobile cæcum and the adhesions, rather than the cause. It seems in addition highly improbable that some 50 per cent. of (table, column 10) men, as indicated by the presence of membranes and bands, have had an acute inflammation without symptoms of the appendix, colon or gall-bladder.

Then, to sum up the argument against the inflammatory nature of these adhesions, there is no proof to show that virulent bacteria or their toxins pass directly through the intestinal wall without injury to it, there is no proof that the wall of the intestines in these cases has been or is the site of an inflammatory injury, and finally there is no proof that the avirulent organisms present in normal tissues ever produce an inflammatory reaction such as would be necessary to account for the formation of peritoneal adhesions. The whole argument in favor of "membranous pericolitis" as the cause of the adhesions under discussion in this paper is entirely hypothetical and as yet without any adequate evidence in its favor, either experimental or anatomical.

Then, too, there is a very definite difference in the appearance of the congenital membranes and of those of inflammatory origin. The former bear a resemblance to a mesentery, are thin and translucent, have connective-tissue strands running in parallel lines and not infrequently, especially about the gall-bladder, contain fat. In addition, in the uncomplicated case there is no scar or other evidence of present inflammatory lesion of adjacent structures. The latter are thicker and opaque, leaving the white, spider-web appearance of a cicatrix. Their connective tissue is not arranged in parallel strands, and they do not enclose fat. There is usually present some inflammatory lesion of an adjacent structure from which the peritoneal inflammation has been derived. So distinct is the difference that one can say that at this point in a single specimen the membranes are congenital and at that inflammatory, a condition not infrequently seen about the appendix, where

one type of lesion is superimposed upon the other. Such an instance is reported by Flint.

Granted, then, that these adhesions occur in the adult in the same location, that they have the same appearance, that there is no adequate evidence of an inflammatory origin, and that the appearance of the congenital and of the inflammatory type is different, then the conclusion seems fairly certain that the former are of the same character as those described in the infant and consequently developmental in origin.

Having arrived at this conclusion it becomes necessary to discuss the method of formation. Hertzler<sup>128</sup> has suggested that although essentially congenital these adhesions are due to varicosities arising from the dilatation of "potential blood-vessels." Such dilatation leads to a hypertrophy of the accompanying connective-tissue fibres and the formation of the membrane. This implies the finding of dilated blood-vessels in these adhesions, which is by no means the rule. In only one case observed in the series was there marked varicosity and this was venous.

Eastman,<sup>77</sup> Cheever,<sup>88</sup> Eisendrath and Schnoor,<sup>95</sup> and many of the more recent writers in the American literature tend to correlate these adhesions with certain anatomical structures. So the parietocolic fold becomes the prototype of the adhesions on the ascending colon such as were described by Jackson, and the plica genito-mesenterica of the adhesions about the terminal ileum. It is to be remembered that the folds and fossæ about the cæcum, appendix and ileum, although not entirely constant, are, nevertheless, definite anatomical structures. To use the names of individuals in connection with these is doubly confusing, first because the same individual has usually described many folds, and, secondly, because it is extremely difficult to ascertain to whom the true credit belongs. It seems much simpler and also more accurate to consider these adhesions as variations of physiological fusion rather than as variations of folds which they frequently but little resemble. This fusing of the peritoneal surfaces, occurring almost simultaneously with the rapid growth of the intestine, serves to explain in every detail the formation of such membranes.

To what extent such congenital adhesions are responsible for disease in the adult is difficult to say, and the data presented in this paper have little bearing on this phase of the subject. One can state, however, that in two or three specimens adhesions about the appendix were of such a nature that they might readily have produced stasis and have been an important factor in the development of an appendicitis in the manner suggested by Spren-  
gel,<sup>129</sup> Dieulafoy,<sup>130</sup> Aschoff,<sup>131</sup> and Albrecht.<sup>117</sup> So, too, the terminal ileum in at least one case was kinked sufficiently sharply because of hyperfixation to suggest the possibility of partial obstruction, and this was also true once in the ascending colon. No instances were noted in which the adhesions about the gall-bladder, although extensive, and extending to the duodenum and transverse colon, definitely produced a kink in either the colon or duodenum. The work of Harris<sup>132</sup> and of Homans<sup>133</sup> in relation to stasis in the duodenum as a result of adhesions in this neighborhood suggest very



strongly this possibility. Although the ampulla of the gall-bladder is normally extremely convoluted, it seems quite probable that stasis in this viscus may at times, perhaps frequently, be as suggested by Gray and Anderson<sup>83</sup> a result of congenital variations in its peritoneal coverings, especially in the region of the cystic duct.

It is certain, indeed, that one can no longer assume a peritoneal adhesion to be pathognomonic of peritoneal inflammation. One must be careful not to make a diagnosis as to some lesion of the intestine from the presence of adhesions alone, for congenital adhesions occur in nearly 50 per cent. of normal abdomens. To put it more concisely adhesions of this type about the terminal ileum, appendix, cæcum, ascending colon and gall-bladder are in themselves of little if any value in diagnosing inflammation. Such a diagnosis must depend upon the pathological picture in the organ itself. Adhesions in these regions may be either causal or coincidental to inflammation or the resultant of it, but in the absence of anatomical evidence of injury to an adjacent viscus they are presumptively congenital and, in the presence of such evidence, very possibly so.

Whether these structures tend to progress or to retrogress as the individual becomes older is not susceptible of determination by the data here presented, inasmuch as the period of observation was far too short. It might be presumed, as was done by Riedel and Lane, that they would follow the general laws of the growth of tissues, and that strain sufficient to cause relatively slight damage would result in a certain amount of reparative effort and hence a thickening along the line of strain, while less than this would produce no change, and greater rupture of the resisting membrane. That this is true of the development of connective tissue elsewhere in the body has been shown by Flint.<sup>134</sup> In such a manner one could conceive of the at first delicate membrane becoming developed into a rather coarse structure as seen in the adult.

The great frequency in this series of both hyperdescent and hypofixation of the colon as well as the observations of Klose, Wandel, Dreicke, and many others indicate that the cæcum with considerable mobility is quite normal, although in a relatively few instances it may give the symptom-complex described by Wilms.

#### X. SUMMARY

1. Variations in the peritoneal attachments of the colon, appendix and terminal ileum have for a long time been well recognized by anatomists and pathologists.

2. Such variations are found frequently in infants, as shown by the examination of 105, between birth and 2 years of age.

3. These variations are identical with certain adhesions seen in the adult about the gall-bladder, hepatic flexure, ascending colon ("Jackson's membrane"), cæcum, appendix and terminal ileum ("Lane's band") and frequently but wrongly ascribed to inflammation.

4. The clinical importance of such variations in relation to the syndrome of "chronic appendicitis" has in the past ten years been well demonstrated.

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# THE MULTIPLE MYELOMATA AND THEIR ABILITY TO METASTASIZE

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THE neoplastic disease described under the caption of multiple myelomata is characterized by foci of growth arising in different parts of the marrow system at approximately the same time, the individual tumors springing from certain primitive cells of the blood-forming series. The disease is rare. It occurs apparently exclusively in individuals over thirty-five years of age and oftenest in men, the proportion being about three to one. Those cases which terminate within six months constitute the rule, although instances are known in which the disease has lasted from three to five years. The bones involved are those with red marrow, notably the vertebræ, sternum, ribs, clavicles, skull, scapulæ and ilium, the marrow in the ends of the long bones of the extremities being relatively seldom affected. The growth replaces the marrow and frequently erodes the bony casement in such fashion as to bring about deformities of various sorts, with or without spontaneous fracture, and is red or greyish-red, depending on the occurrence of hemorrhage or the degree of vascularity, occasionally cream-colored or whitish.

The symptomatology of the multiple myelomata depends largely on the size, number and distribution of the growths, and on the production of deformities, although the occurrence in the urine of the peculiar protein first described by Bence-Jones constitutes a symptom of great value in those cases in which tumor nodules have not yet become obvious, and of confirmatory significance in those cases where nodular or other deformities are already evident. The appearance of deformities, however, is usually preceded by a period during which the patient complains of persistent, deep-seated pains, the cause of which is not apparent and the nature of which is consequently apt to be misinterpreted as rheumatic, neuralgic or neurotic. The pain, which is almost always referred to the same region, is frequently worse at night and is accentuated by movement. In some cases it is fugitive and not very intense; at other times it occurs in paroxysms which are so severe as to incapacitate the patient for days at a time, disappearing only to reappear with equal or increased intensity. In still other cases the pain is continuous, lancinating or boring in character, and of such ferocity that the patient's fortitude is soon exhausted. Pain of the sort described, unless otherwise explicable, should arouse suspicion of a myeloma or of one of the several clinically related neoplastic lesions of the marrow system, or of a

deposit from a primary growth whose metastases express a predilection for the bones, such as tumors of the thyroid, prostate, stomach, adrenal, etc. The use of the X-ray is helpful in determining the existence and location of circumscribed metastases, but in the case of diffuse metastatic or myelomatous infiltration of the marrow, the X-ray sometimes is powerless to register a shadow. It is an observation of value, also, that, while the presence of the Bence-Jones proteinuria is not pathognomonic of the multiple myelomata, its detection has several times led to the correct diagnosis before the expansion of the tumor nodules in the bony system had reached such a grade as to fall within the scope of ordinary diagnostic methods.

When the deformities of the bony system occasioned by the multiple myelomata become visible or palpable, the age and sex of the patient and the distribution of the tumors are sufficient to establish the nature of the process with reasonable assurance, particularly if the urine reveals the reactions for the Bence-Jones body. Primary tumors of the bony system are known, however, in which the distribution is identical with that of the myelomata, and in a few cases of metastatic carcinomata of the bones the urine has yielded the characteristic reactions for the Bence-Jones protein. In a disease described by Symmers and Vance the patient complained of exquisite pains in the back, hip and axilla, and tumors were present in the sternum, humerus, occiput, vertebræ, ribs and ilium, microscopic examination revealing multiple primary intravascular hemangio-endotheliomata with the formation of subsidiary vascular channels within many of the parent capillaries of the growth, and Seegelken has described a case in which there were multiple primary chondrosarcomata of the vertebræ, sternum and ribs. In neither case was the Bence-Jones protein found in the urine. Barry and Martland have described a condition attended by multiple tumors in the tibiæ, clavicles, scapulæ and other bones, the microscopic appearance being that of a spindle- and giant-cell growth easily distinguishable from the myelomata and other primary tumors of the bones, although the clinical manifestations are much the same. Recognition of this variety of growth is imperative, since operative removal of each growth as it arises promises a chance of cure. Moreover, the bony system may become metastasized from a clinically undetectable primary growth in such manner as closely to simulate the distribution of the myelomata. This fact is of moment in that a small primary carcinoma of the thyroid, for example, may metastasize the ribs, sternum, clavicle or other accessible bones in a way that operative interference directed toward both the primary growth and its metastases promises the only hope of relief.

Of the bones involved by the multiple myelomata the vertebræ are perhaps oftenest concerned. The process usually is first shown clinically by the appearance of pains which radiate down the legs, into the arms, or around the trunk. The distribution of the pains in the legs may be such as to suggest sciatica, and, in these circumstances, the growth is to be sought in the lumbar spine or in the sacrum. Involvement of the thoracic or lower cervical

vertebræ is attended by pains corresponding to the distribution of the superficial sensory nerves of the part or even to the visceral ramifications. In the upper cervical region the presence of myelomata in the marrow of the vertebræ is not uncommonly manifested by neuritic pains in one or both arms, sometimes associated with motor or trophic disturbances due to pressure on the upper reaches of the brachial plexus. In still other cases, the growth of the tumors in the vertebræ results in disintegration of the intervertebral discs, collapse of the bodies, the production of a kyphos and the symptoms of pressure on the cord. Several such cases have been subjected to operation with temporarily beneficial results.

In some cases the existence of myelomata is first suspected when, as the result of some natural movement or following slight traumatism, fracture ensues. The fractured bone is usually painless except on manipulation, and union does not occur even when the approximated ends are at rest. On the other hand, union has been known to result even without the aid of artificial devices, notably in the ribs.

*Histogenesis.*—The commencement of the process of blood formation in the bone-marrow is marked, according to Maximow, by the migration into the perichondrium of the pre-bony cartilage of certain star-shaped cells which differentiate into two primary forms, namely, fixed cells, representing the precursors of the reticulum and of the osteoclasts and osteoblasts; and myeloblasts, from which are derived the granular leucocytes and the erythroblasts. The weight of histological evidence seems to favor the view that the myeloma is a tumor composed of myeloblasts, although certain derivatives of the myeloblasts, namely, the neutrophilic myelocytes and the erythroblasts have been implicated, Ribbert having described a so-called erythroblastoma of the bone-marrow, and Sternberg and others, myelomata which were composed of what were regarded as neutrophilic myelocytes. Christian, on the basis of slight differences in the size of the cells and in the arrangement of the nuclear chromatin, distinguishes between the myeloblast and a so-called plasma-cell peculiar to the bone-marrow, from the latter of which, he assumes, a type of myeloma originates. It is to be noted in this connection that the plasma-cell of the tissues, which is found over a wide distribution and in a great variety of pathological conditions, is a cell of characteristic and easily recognizable structure, about whose origin, function and destiny, however, absolutely nothing is known. It is a morphological unit, but otherwise an enigma. The "bone-marrow plasma-cell," on the contrary, is not even a distinctive morphological unit, since it bears such a striking resemblance to the myeloblast that even experienced microscopists find it difficult, if not impossible, to differentiate between the two, as shown by the fact that, in one of Christian's cases of myeloma in which he designated the cells "bone-marrow plasma-cells," the same tumor, examined by MacCallum, was interpreted as a growth of myeloblasts. With Forman and Warren, I have had occasion to observe, in one and the same tumor, cells which, according to the criteria advanced by Christian, could be interpreted as myeloblasts,

while in the same field were numbers of cells which, by the same token, would be regarded as plasma cells of the so-called bone-marrow type. It seems to me that they represent slightly different stages in the development of the same cell. The oxydase reaction which, in theory at least, should permit differentiation between the plasma-cell and myeloblast, does not always fulfil its promise in this respect, and, indeed, this is to be expected, for the reason that the oxydase reaction is a phenomenon whose occurrence is subject to the vagaries of living cells. Because the myeloblasts of the normal marrow and of some myelomata yield a positive oxydase reaction is no sign that the myeloblasts of all myelomata should be similarly responsive. A positive oxydase reaction is of distinct value, but a negative reaction is, I believe, meaningless as far as the recognition of the neoplastic myeloblast is concerned. Interesting in this connection is an observation of Dr. Alexander Fraser, who, in attempting to differentiate between the cells in the exudate of croupous pneumonia by means of the oxydase test, found that morphologically typical polynuclear neutrophiles not uncommonly failed to respond, while other neutrophiles in the same microscopic field reacted definitely. From this it is to be assumed that the polynuclear leucocyte either loses the ability to react in certain circumstances or that it sometimes fails to acquire it, and the same would appear to be applicable, possibly with even greater force, to the myeloblast which is proliferating rapidly and under the influence of an abnormal stimulus such as obtains in the process of myelomatosis. In the myeloma studied by Forman and Warren, the oxydase reaction was positive, the granules occurring in the great majority of the tumor cells, not alone in those cells which, morphologically, were indistinguishable from the plasma-cell described by Christian, but in those cells whose structure entitled them to classification as myeloblasts. These investigators infer from this observation that many of the myelomata which have been described as plasma-cell tumors were probably composed of myeloblasts. In Vance's case of myeloma, in which the cells were of the myeloblastic variety, the oxydase reaction was negative. In both of my cases of myeloma it was likewise negative, one of the tumors showing a preponderance of cells of the sort described by Christian, the other composed largely of myeloblasts with a pronounced admixture of so-called plasma-cells and of degeneration forms.

Unlike the plasma-cell, the myeloblast is a cell about whose genesis and derivatives there is certain definite information. Although the plasma-cell of the tissues is a characteristic architectural entity, beyond that practically nothing is known of it. To postulate a variety of plasma-cell peculiar to the bone-marrow and the origin of a tumor from it, not only challenges assent without proof, but constitutes an assumption which does not seem to be warranted by the desirability for such an interpretation, since it does not make for clarity and must remain valueless as a working hypothesis until the cycle of the plasma-cell is determined with something akin to finality. Until that time, and until the existence of a type of myeloma composed of erythro-



blasts or of neutrophilic myelocytes is more securely established, I can see no justification for disregarding the view that the myeloblast is the only cell from which it is possible for a genuine myeloma to spring.

Since the establishment of the Pathological Laboratories at Bellevue Hospital twelve years ago only three cases of multiple myelomata have been encountered in over 6000 autopsies. One of these cases has been studied and recorded by Vance, the other two are included in this paper. Of these, one was a case marked by certain instructive clinical features, by exceptionally widespread growths, particularly in the skull, by an unusually rapid course, and, histologically, by the occurrence of tumors composed of cells morphologically indistinguishable from myeloblasts, but which failed to respond to the oxydase reaction. The other was a case attended by apparently genuine transplantation metastases in the intercostal muscles and in the fat around one of the suprarenal capsules.

CASE I.—The patient, a man aged thirty-seven years, a painter, was admitted to the medical service of Doctor Guile, at Bellevue Hospital, with the statement that, seven weeks previously, he experienced throbbing pains in the outer half of the left clavicle attended by slight redness and swelling of the affected region. The pains soon spread to the middle of the clavicle and, finally, to the sternoclavicular joint, which became painful, swollen and slightly reddened. Three weeks later the region of the right knee-joint became reddish and was the seat of violent, throbbing pains. At the same time pains of a similar description appeared in the region of the ribs corresponding to the anterior axillary line on both sides of the body, and in the right clavicle. Synchronous with the appearance of the pains in the left clavicle a swelling became evident on the right side of the forehead, and was rapidly followed by other nodules in the skull. There was no headache, but the patient complained of inability to sleep because of the pains in the several parts of the bony system involved. At the time of admission physical examination showed two nodules beneath the skin covering the forehead, that were soft in consistence. One was slightly tender, the other was not tender at all. The left sternoclavicular joint was enlarged to form a globular, tender mass which felt cystic. The outer half of the right clavicle was tender and showed two irregular, nodular areas of thickening. The ribs showed several tender nodules covered by apparently intact bone. The region of the head of the right fibula was tender, as was that of the inner side of the lower end of the right femur. During the patient's stay in the hospital the nodules in the skull increased in number, the clavicles yielded distinct crepitus, and crepitus was felt in the head of the right fibula and in the ribs. About three weeks after admission the patient exhibited slight œdema of both eyelids on the right side, and complained of throbbing sensations in the eye itself. Ophthalmoscopic examination of the eye ground on the right side showed some congestion of the veins of the fundus.

The urine revealed the characteristic reactions for the Bence-Jones protein on innumerable occasions.

At the time of admission examination of the blood showed 12,000 white cells, of which 77 per cent. were polynuclear neutrophils, 15 per cent. lymphocytes, 3 per cent. myelocytes, and 5 per cent. large mononuclear cells. Three weeks later the differential count was about the same, although the myelocytes were present to the extent of 5 per cent.

*Autopsy* (No. 5692).—The body was that of a markedly emaciated man, thirty-seven years of age. On the anterior surface of the right forehead about 2 cm. beyond the middle line was an irregularly rounded, soft, almost fluctuating projection which measured 4 cm. in diameter. The right pupil was in mid-dilatation and the left was almost completely dilated. In the region of the left sterno-clavicular articulation was a large rounded mass, the skin over which was intact. On palpating this mass, which was soft in consistence, a fine, crackling sensation was imparted to the finger. Over the right clavicle, at the junction of the outer third with the inner two-thirds, was a mass which likewise yielded distinct crepitation. The anterior surface of the chest was flattened, the sternum having fallen in, so that the costochondral articulations on both sides were noticeably angulated. Crepitation could be felt over several of them. Moderately soft, rounded or oval nodules could be felt beneath the skin over certain of the ribs on both sides of the body.

On removing the lungs there was found on the right side of the intra-thoracic portion of the body of the fourth dorsal vertebra a rounded, rather soft projection which measured 5 cm. in diameter and was covered by intact pleura. The seventh rib on the left side presented a long cylindrical swelling which was enclosed by apparently intact bone. On section, the swelling corresponded to greyish tumor which completely replaced the marrow for a distance of several centimetres in the long axis of the bone. The sixth and ninth ribs on the right side near the costochondral junction showed similar swellings.

On opening the right femur a large, irregularly rounded, reddish, softened tumor mass was found near the lower end. A similar but smaller mass was present in the head of the right fibula.

On reflecting the scalp the calvarium was found to be riddled with large and small tumors which varied in size from the head of a pin to several centimetres in diameter. The smaller ones gave a moth-eaten appearance to the calvarium, being present, literally, by dozens. Some lay in the marrow and were enclosed by intact bone; others had pushed their way through the bony substance and lay flush with the outer surface of the skull, the bone over them having been completely replaced or remaining as a fine parchment-like sheet riddled with minute openings. Several of them, however, projected inward and pushed the dura before them, none of them actually penetrating the dura. On section they presented a soft, deep bluish or bluish black appearance, with scattered greyish islands of tissue. On either side of the head, corresponding to the temporal bone just back of the outer angle of the palpebral fissure, tumor nodules projected directly inward and through the orbital plates of the frontal bones, pressing upon the external fibrous covering of the eyeballs. The right middle fossa presented a large, globular swelling which pointed upward into the cavity of the cranium for a distance of about 2 cm. It was covered by a thin shell of finely reticulated bone. On cutting into this mass it was found to consist of a quantity of soft, hemorrhagic tumor tissue extending directly into the cavity of the middle ear.

*Histology*.—Sections were removed from tumors in various parts of the body. The prevailing cell was rather large, rounded or polygonal, depending upon the degree of pressure, with slightly basophilic cytoplasm and a vesicular, eccentrically placed nucleus and a delicate chromatic reticulum along which were

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scattered coarser chromatin particles. The cells were supported by a fine connective-tissue reticulum. In places the growth was richly vascularized, in other places hemorrhagic.

*The Metastasizing Myelomata.*—A noticeable feature of the myeloma consists in a tendency on the part of the growth to confine itself to the marrow system. In fact, it is frequently stated that, while the growth may erode the bony casement and bring about continue infiltration of adjacent structures, it does not produce metastasis by transplantation of cells, either in the marrow itself or in alien tissues. It is quite generally agreed that each myeloma represents a primary growth, that each tumor arises in response to the same sort of stimulus, and that the presence of hæmopoietic tissue, if not a prerequisite to development, is at least a preferential medium. In view of the fact that hæmopoietic tissue is known to exist in certain localities beyond the confines of the bony system, it seems reasonable to assume that myelomata might develop in such tissue, either in the form of growths independent of those in the marrow and yet arising in response to the same provocative agent, or, possibly, as the result of the implantation in prepared soil of tumor-cells from a growth in the marrow.

In embryonal life the liver and spleen are hæmopoietic organs auxiliary to the bone-marrow, but in extra-uterine life the marrow assumes the task of hæmatogenesis to the exclusion of the liver and spleen, although their function in this regard may be at least partially reawakened if, for any reason, the marrow is so altered that its blood-forming function is diminished. It is known, for example, that, in pernicious anæmia and other conditions attended by interference with regeneration of blood-cells, myeloid foci are sometimes present in the liver and spleen, and it is commonly held that they represent hyperplasia of pre-existing hæmopoietic tissues in which the function of hæmatogenesis has been recalled. That this reversion may proceed to a marked extent is indicated by those extraordinary examples of acute myelogenous leukæmia in which the bone-marrow reveals not the slightest indication of hyperplastic reaction, but displays a poverty of cells or is actually sclerotic, the flooding of the circulation by myelocytes being accomplished, it is maintained, as a result of the activity of the rejuvenated hæmopoietic tissues in the liver, spleen and elsewhere. In other circumstances the presence of myelocytes and myeloid giant-cells in such tissues as the spleen and liver is explained on the basis of embolism from the bone-marrow, and, since the recipient tissues were originally members of the hæmopoietic system, it is to be assumed that they still offer an attractive lodgement for cells from the bone-marrow, and even a favorable medium for proliferation. These views are of practical importance in the interpretation of those cases of myelomatosis in which tumors of a nature identical with those in the bone-marrow are found in tissues outside the osseous system.

Cases have been recorded under the title of multiple myelomata in which so-called metastases were described in different parts of the body, but

in several of these cases the nature of the neoplastic process in the marrow is open to serious doubt. In the case recorded by Herrick and Hektoen, the sternum, ribs, spine, skull and humerus were involved by a tumor the cells of which were apparently of the lymphoid series, and both ovaries contained nodules of the same cellular composition. The same objection applies to the cases of Weber, Scheele and Herxheimer, and Kahler, in all of which there is doubt as to the propriety of including the growths in the marrow in the category of the myelomata. In other recorded cases, however, the diagnosis of myeloma is entirely acceptable. In the case of Hoffman the tumors in the bony system were distributed in characteristic fashion, and the cells were myeloblasts. The liver enclosed nodules of identical composition with the growths in the marrow. In a case recorded by Charles and Sanguinetti, the vertebræ and ribs were involved by multiple growths of myeloblasts. Lymph-nodes enlarged to the size of filberts were found over the right common iliac artery, and contained cells of the same sort as those encountered in the medullary tumors. There was no erosion of the vertebræ and the enlarged nodes were obviously independent of any source of direct infiltration. In one of Christian's cases, the skull, ribs and vertebræ were involved and there was a nodule in the axilla and neoplastic foci in the soft tissues of the arm. In Shennan's case, the liver revealed nodules associated with myelomata of the ribs, and in the case of Schütz the right tonsil was involved. In a case reported by Pepper and Pearce, the spleen was diffusely infiltrated by tumor-cells identical with those encountered in multiple growths in the ribs, pelvis and vertebræ, and similar cells were arranged focally in the liver.

It is a significant fact that, with the exception of a case recorded by Christian, all of the so-called metastatic deposits referred to occurred in tissues which, in embryonal life, are part of the myelocytic hæmopoietic system; namely, the liver, spleen and lymph-nodes. In the liver and spleen embryonal hæmopoietic foci are well recognized and are composed largely of myeloblasts. That the lymph-nodes, however, are part of the extra-medullary myelocytic hæmopoietic system is not so generally accepted. Nevertheless, in certain aplastic lesions of the bone-marrow, Butterfield has noted the presence of typical myeloid foci in the lymph-nodes, so that the interpretation appears to be allowable that myelomatous formations in the lymph-nodes may be produced by hyperplasia of residual myeloblastic foci. In Christian's case, of course, a similar interpretation would be strained, since it presupposes the existence of myeloblastic hæmopoietic tissues in parts where they have never been demonstrated. It seems more reasonable, therefore, to regard the nodules in his case as genuine transplantation metastases.

In connection with the question of metastasis in myelomatosis by the transplantation of cells, the following case is significant:

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CASE II.—A man, aged fifty-one years, was admitted to Bellevue Hospital in a semicomatose state with the classical signs of cardiac decompensation. It was learned, however, that eight years before admission the patient suffered a fall, striking the right shoulder. For a year thereafter the shoulder was more or less swollen and painful. For three months previous to admission the patient complained of rheumatic pains in the right shoulder, and finally lost the use of the arm entirely, but whether suddenly or not the history does not state. Physical examination showed marked enlargement of the heart and a double murmur at the base. The head of the right humerus was markedly enlarged and crepitation was felt. The urine revealed no Bence-Jones protein.

*Autopsy* (No. 4674).—The body was that of a negro man, fifty-one years of age, of well-developed frame. On the side of the head, about 3 cm. back of the external angle of the left eye, was a slightly elevated, circular growth which projected directly through the outer table of the skull and was delimited by a rim of bone. The skin over it was intact. The upper third of the right humerus was greatly enlarged and the bone was fractured. The medulla of this part of the humerus was occupied by a quantity of greyish red, soft tumor material. In the medulla of the third rib on the right side about an inch from the costochondral junction was a small, reddish nodule, soft in consistence, the hard bone on either side being intact. In the intercostal muscles between the sixth and seventh ribs on the right side was a mass of reddish tumor tissue, the ribs on either side being intact. Lying in the fat tissues immediately adjacent to the left suprarenal capsule was a soft reddish nodule which was rounded and measured 1.5 by 2 cm. The vertebræ were intact throughout.

*Histology*.—Microscopic examination of the tumors in the humerus, in the third rib, in the intercostal muscles and in the fat around the adrenal revealed growths composed, for the greater part, of rather large, rounded or polygonal cells, each of which enclosed an excentrically placed nucleus with a fine chromatic reticulum and coarser chromatic particles arranged at irregular intervals against the cell membrane. The cytoplasm was pale or slightly pinkish in color and smooth. Scattered among these cells, which were of the type usually described as myeloblasts, were fairly large numbers of cells whose nuclei presented slightly different structural characteristics in that the chromatic network was stippled with coarse granules, thus corresponding to the nuclei ordinarily encountered in the so-called plasma-cell. In certain sections a third type of cell was found, likewise in fairly large numbers. These cells varied in size. Each was provided with a densely staining, small nucleus, often excentrically placed, and with very finely granular, reddish staining cytoplasm. They were evidently degeneration forms.<sup>1</sup>

This case and the case recorded by Christian, in which there were secondary neoplastic nodules in the soft parts of the arm and in one axilla, appear to represent the only really indisputable examples of genuine metastatic myelomata to be recorded, both of them effectually violating the generally accepted dictum that the myelomata do not metastasize by cell transplantation.

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<sup>1</sup> Cells of an exactly similar type were described by Vance in his report of a myeloma studied in this laboratory. These cells, I take it, are the same as those described by Ribbert as erythroblasts.

CONCLUSIONS

1. The so-called multiple myelomata represent neoplastic growths which spring from myeloblasts.
2. Since the term multiple myelomata is broadly inclusive, the designation of the neoplastic disease under consideration might, I think, appropriately be changed to that of multiple myeloblastomata.
3. The multiple myeloblastomata are capable of originating growths in the extramedullary hæmopoietic viscera by hyperplasia of pre-existing myeloblastic foci, and in certain other tissues by the process of metastasis by cell transplantation.

## THE PROGNOSIS AND TREATMENT OF EMPYEMA

WITH RESPECT TO THE SHAPE OF THE CAVITY AND THE RELATION OF THE LUNG TO THE  
CHEST WALLS \*

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As a result of general familiarity with the use of the hollow needle, the diagnosis of acute empyema has become increasingly easy. Prognosis, on the other hand, more especially in respect to ultimate cure, is uncertain. Why in one instance a very large foul cavity heals rapidly and in another a cavity apparently more susceptible of closure is never obliterated is a matter of considerable obscurity. Patients suffering from empyema are not on the whole attractive subjects for study, yet a close inquiry into the process of healing is not without its fascination, and perhaps profit.

Healing in acute empyema takes place under a number of favorable influences, among which the following appear to be the most important: The fact that the thorax can easily be drained at its most dependent point; the remarkable circumstance that, when infected, the pleural surfaces tend to become covered with a thick layer of fibrin slowly organized and correspondingly slow to adhere to an opposing surface; the ease with which negative pressure within the thorax is restored after operation; and the very considerable collapse of which the walls of at least one side of the thorax are capable, thereby rendering a complete reëxpansion of the lung unnecessary. These influences are to a great extent interdependent. Each is worthy of separate consideration.

The ease with which the chest is drained is accounted for by the shape of the diaphragm which makes a deep narrow angle with the chest wall: Thus the chest is deepest where it is most accessible, and drainage in the posterior axillary line is perfectly dependent with the patient in a reclining position. Rapid conquest of infection is thus favored.

The failure of the pleural surfaces to adhere readily was pointed out by Schede<sup>1</sup> many years ago. He alluded particularly to the heavy fibrin membrane which makes the healing of long-established empyema so difficult; but in reality the active formation of fibrin on the pleural surfaces has a more important significance. If the pleura had, in empyema, the same characteristic adhesiveness as the peritoneum, the collapsed lung could never expand, and few cavities would close. The abundant secretion of fibrin so generally noted at operation is, therefore, conservative, and the very slowness with which the bloodless fibrin layer adheres to an opposing surface is a positive aid to expansion of the lung. It appears to be true that in its first

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\* Read before the Boston Surgical Society, April 1, 1918.

deposition, in pleurisy, as a thin layer, the fibrin covering the pleura is rapidly organized and a source of early adhesion. As a thick layer in fully developed empyema it tends, perhaps, to act at first as a lubricant; when finally organized it becomes a very avascular scar tissue, capable for months or even years of being stripped cleanly from the lung or chest wall, and leaving behind only a few small bleeding points upon a normal pleural surface. If applied to a similar opposing surface it slowly adheres.

There are problems here to be worked out. Is the fibrinous exudate a characteristic reply to the pneumococcus? Or is it due to physical and chemical characteristics of the pleural surface? Why, since the pleura offers to the pathologist the most beautiful demonstration of the organization of an exudate, is the organized fibrin layer of empyema so bloodless? How is it possible to strip it for years after its formation without injury to the lung?

The restoration of negative pressure within the thorax is, of course, the influence which expands the lung. Artificial means of establishing it are, as a rule, unnecessary. Even before the wound in the thorax is smaller than the primary bronchus leading to the collapsed lung, the wet dressing acts somewhat as a valve. Later, as the opening closes, coughing and active respiratory movements tend to inflate the lung.

In this connection the operation for acute empyema advocated by Lilienthal<sup>2</sup> is of interest. To widely open the chest by rib spreading, to thoroughly cleanse and free the pleural surfaces, encouraging the lung to immediate expansion, should hasten healing. The possibility of splitting the friable parietal pleura into the diaphragm or the mediastinum may prove to be a real danger. The operation is not yet established for routine use even among patients presumably able to bear it, and its advocates advise preliminary aspiration drainage in particularly sick and toxic patients.

The reduction of the capacity of one side of the thorax is brought about by the rise of the diaphragm (always noteworthy as demonstrated in Röntgen plates); by the curvature of the spine *away* from the diseased side, allowing the ribs of that side to fall together from above downward; and by the drawing over of the mediastinum (most easily noted by change in position of the heart shadow).

If one follows the healing of an acute empyema both clinically and in a series of stereoscopic plates, one is able to appreciate in most instances the steady and apparently resistless effect of these four favorable influences. One is able, likewise, to note their failure under unusual conditions. Studies made at the Peter Bent Brigham Hospital during the last four years bring out the fact that the failure of the lung to remain free, particularly the failure of certain portions of the lung to remain free in the early stage of convalescence is the usual origin of the chronic empyema cavity. In this connection it will occur to everyone equally familiar with the disease in children and adults that in operating on children, especially those whose chests are small enough to be fairly well explored with the finger, the surgeon can usually assure himself that the lung is free to expand. More particularly,



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Lloyd<sup>3</sup> has demonstrated in children that by making a large enough incision it is quite possible and of definite advantage completely to free the lung of adherent fibrin masses and obtain immediate expansion. In adults, on the other hand, one may find, as a result, perhaps, of neglect in an acute case, that the lung is already firmly adherent, and on account of the size of the cavity and difficulty of orientation be unable to free it. It is, I believe, correct to say that as compared with adults the acute empyema of children heals more promptly and effectively.

Theoretically, an absolutely non-adherent lung should be the ideal finding in acute empyema, but it has appeared in the Brigham series that while adhesion of the lung in certain positions is most disadvantageous, in others it is actually favorable to healing. Notably, collapse and adherence to the mediastinum of the lower circumference, which normally fits into the costo-diaphragmatic angle, makes expansion impossible. On the other hand, if the lower angle becomes fixed well out upon the diaphragm, expansion seems always to occur. This condition has so frequently been found in the Brigham series and has proved to be of such favorable significance as to suggest an inquiry as to how it comes about. In one instance (Case I) a pleurisy is known to have preceded by some months the pneumonia which resulted in empyema, and indeed such adhesions, due to earlier pulmonary disturbances, may well be expected in adults. It is also conceivable that, in a lower lobe pneumonia, the inferior surface of the lung may often become sufficiently fixed during the course of the disease to remain adherent to the entire surface of the diaphragm when the rest of the lung is pressed away from the chest wall by the gathering exudate. The position of the apex at an early stage seems to make very little difference. Even when it has remained collapsed for a long time, expansion may take place provided the lower angle is in good position.

In general, if attachments of the lung occur in such a way as to leave the surface of the collapsed lung convex after drainage, complete expansion cannot occur. If, on the other hand, the lower angle of the lung becomes fixed at or near its natural position so as to leave the outer face of the lung concave, that concavity can quite readily belly out and become applied as a convex surface to the chest wall. The matter seems to be one of available lung surface. If, early in healing, the available lung surface which can be applied to the chest is limited, expansion will be incomplete. If enough surface is available the lung will always, even if slowly, fill the thorax.\*

The following silhouettes taken from stereoscopic plates illustrate the course of the disease in a number of typical cases. The diagrams are accurate in showing two dimensions of the cavities, which are colored solid black. The curve of the diaphragm is drawn as a solid line and the heart shadow shown by broken diagonal lines. Curvatures of the spine are indicated. The chest is seen from behind.

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\* The exception to this rule is due to the complication of a bronchial fistula which, of course, prevents the establishment of negative pressure within the thorax.

CASE I.—*Apex and lower angle in good position. Concave surface* (Figs. 1-4). D. W. C. Surg. 4147. Acute right-sided empyema following pneumonia. The patient had previously suffered from a fibrinous pleurisy which had left very high diaphragm and had, perhaps, fixed the lower angle of the lung.

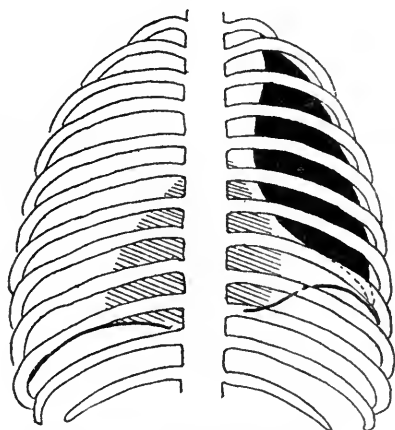


FIG. 1.—Case I. January 18, 1916. Shows condition the day before operation. Note high diaphragm on side of empyema. Patient had had a pleurisy on this side some months before.

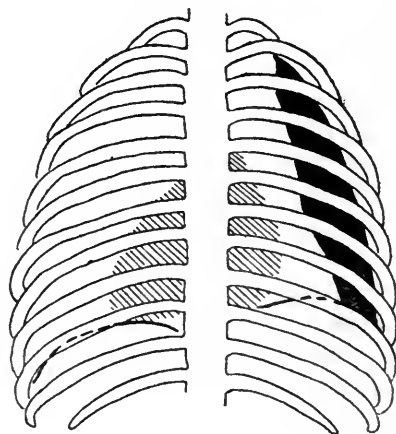


FIG. 2.—Case I. One week after operation.

Fig. 1, January 18, 1916, shows condition the day before operation. Note high diaphragm on side of empyema. Patient had had a pleurisy on this side some months before.

*Operation* (January 19, 1916).—Drainage by rib resection. The

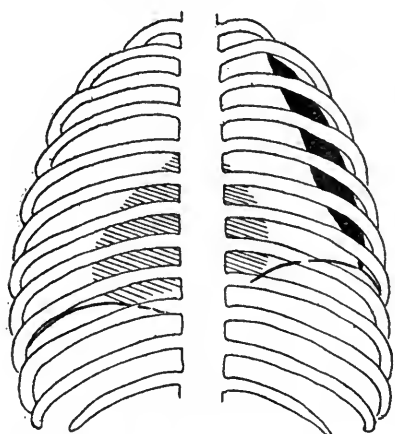


FIG. 3.—Case I. Two weeks after operation.

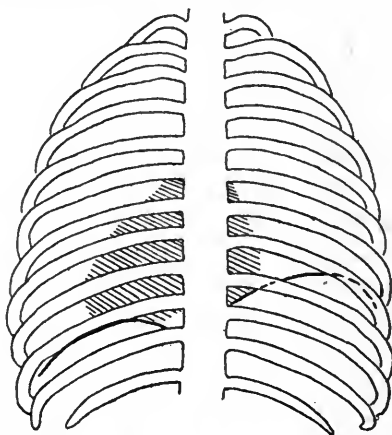


FIG. 4.—Case I. Four weeks after operation. Cavity obliterated.

empyema cavity was principally anterior and the opening was necessarily made in the anterior axillary line, a position rather unfavorable for drainage.

Fig. 2 shows condition one week after operation. Fig. 3, two weeks

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after operation. Fig. 4, four weeks after operation. Cavity obliterated. The sinus was healed February 17, 1916, one month after operation.

Result June, 1917—well.

CASE II.—*Apex collapsed, lower angle in good position. Concave*

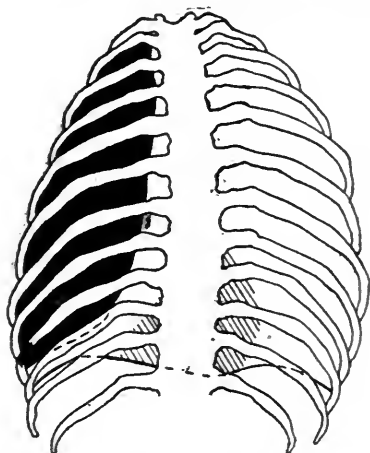


FIG. 5.—Case II. Soon after operation. Upper lung completely collapsed. Lower angle well filled. Heart pushed to right.

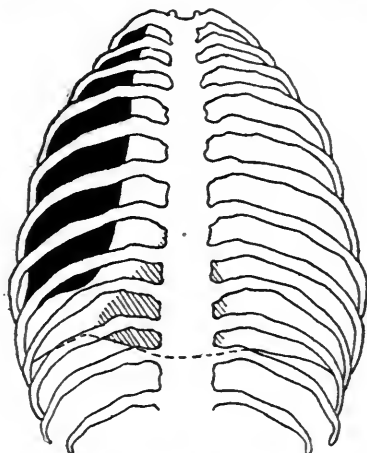


FIG. 6.—Case II. May 19, 1916. Partial expansion. Heart in normal position.

surface (Figs. 5-7). T. J. G. Surg. 4483. Subacute left-sided empyema of unknown etiology of two weeks' duration before entrance to hospital. Pyopneumothorax.

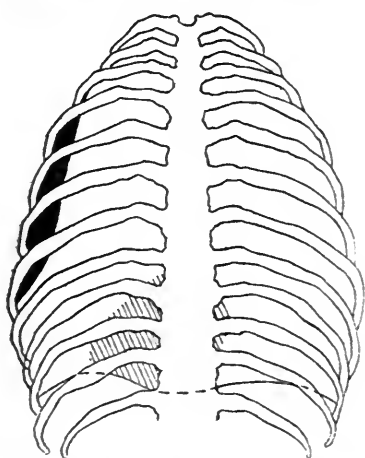


FIG. 7.—Case II. January 31, 1917. Cavity nearly obliterated. Pleura thickened.

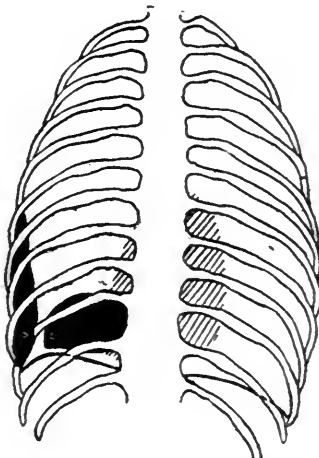


FIG. 8.—Case III. Four days after operation. Marked expansion of lung has already occurred. Diaphragm rising and carrying attached lung toward thoracic wall.

*Operation* (March 27, 1916).—Drainage by rib resection. Lung found collapsed above but adherent well out into costodiaphragmatic angle below.

Fig. 5 shows condition soon after operation. Upper lung completely

collapsed. Lower angle well filled. Heart pushed to right. Fig. 6, May 19, 1916, partial expansion. Heart in normal position. Fig. 7, January 31, 1917, cavity nearly obliterated. Pleura thickened.

Result June, 1917—well.

CASE III.—*Apex in good position. Lower angle attached by a narrow adhesion to outer portion of diaphragm* (Fig. 8). E. P. O'N. Surg. 7511. Acute left-sided empyema following pneumonia (entire left lung).

*Operation* (October 10, 1917).—Drainage by rib resection, low and posterior. 3000 c.c. pus.

A very thin ribbon of considerable depth anteroposteriorly was attached to junction of outer and middle thirds of diaphragm, dividing the chest into two communicating cavities. This ribbon apparently represented the fibrin-covered compressed left lower lobe. It was not disturbed. Tube drainage.

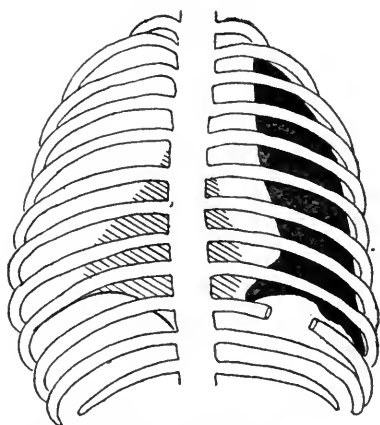


FIG. 9.—Case IV. September 9, 1914. One month after original operation. Lower angle adherent to mediastinum. Surface of lung convex.

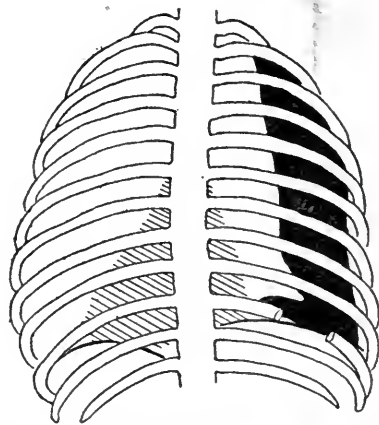


FIG. 10.—Case IV. October 28, 1914. Lower angle free. Slight lateral curvature.

Fig. 8 shows condition four days after operation. Marked expansion of lung has already occurred. Diaphragm rising and carrying attached lung toward thoracic wall.

February 20, 1918: Healed. Eighteen pounds gain in weight.

CASE IV.—*Apex in good position. Lower angle retracted. Convex surface* (Figs. 9–12). G. G. Surg. 1661, 2215. Acute empyema following pneumonia. The usual rib resection performed, but suction drainage resulted in complete collapse of lower part of lung which became fixed.

Fig. 9, September 9, 1914, one month after original operation. Lower angle adherent to mediastinum. Surface of lung convex. Decortication advised.

*Operation* (September 9, 1914).—Decortication by rib spreading approach in fifth interspace. Lung freed and expanded at once. Suction drainage again resulted in collapse of lung and again fibrin layer was removed and lung freed.

## PROGNOSIS AND TREATMENT OF EMPYEMA

Fig. 10, October 28, 1914, lower angle free. Slight lateral curvature. During November, 1914, drainage opening closed and opening had to be reestablished. Fig. 11, December 31, 1914, lung expanding and is fairly well out upon diaphragm. Fig. 12, October 28, 1915, cavity almost healed. Unusual lack of chest deformity and rising of diaphragm.

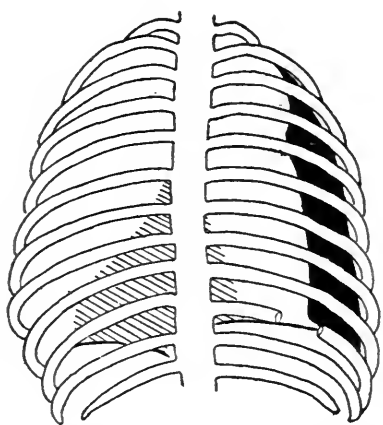


FIG. 11.—Case IV. December 31, 1914. Lung expanding and is fairly well out upon diaphragm.

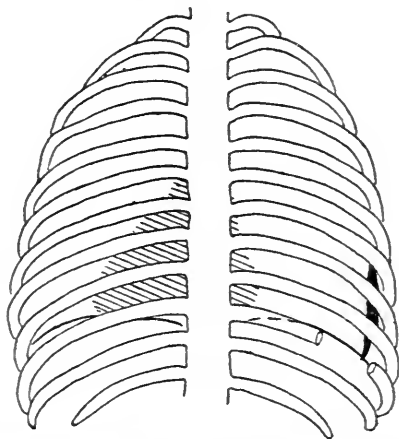


FIG. 12.—Case IV. October 28, 1915. Cavity almost healed. Unusual lack of chest deformity and rising of diaphragm.

almost healed. Unusual lack of chest deformity and rising of diaphragm.

Result, March, 1917—well. It is interesting to note that clubbed fingers developed in this case and later returned to normal.

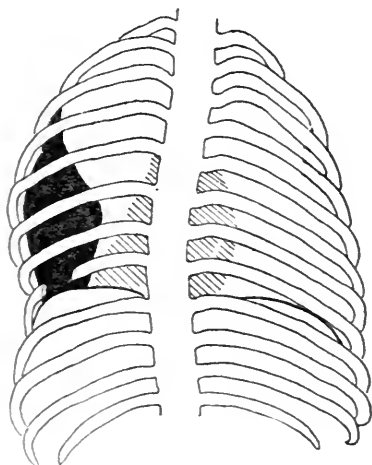


FIG. 13.—Case V. Shows upper lung filled out. Lower angle retracted against pericardium. Unusual spinal curvature which has diminished the breadth of lower part of cavity.

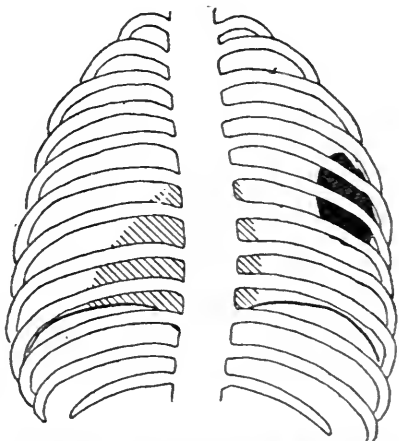


FIG. 14.—Case VI. Unusual localized failure of expansion explained by bronchial fistula.

CASE V.—*Apex in good position. Lower angle retracted. Convex surface* (Fig. 13). M. B. Surg. 4440, 5739. Chronic empyema of five years' standing, following drainage of acute empyema. Patient

exhibited retarded development and pronounced signs of chronic pulmonary infection. Foul cavity.

Fig. 13 shows upper lung filled out. Lower angle retracted against pericardium. Unusual spinal curvature which has diminished the breadth of lower part of cavity.

Patient has been treated by Schede operation in many stages. A small cavity still exists, but is clean and well drained. Marked improvement in health. Further plastics may be necessary. Decortication would have been highly desirable, but was a surgical impossibility.

CASE VI.—*Local cavity due to bronchial fistula* (Fig. 14). M. C. Surg. 4418, 4898. Patient entered hospital a year after drainage of neglected acute empyema.

Fig. 14, unusual localized failure of expansion explained by bronchial fistula.

A local Schede operation was performed which resulted in further collapse of lung. Death in a few months of pulmonary tuberculosis. Probably the patient would have lived longer had no attempt been made to obliterate the cavity.

These selected cases illustrate the more important types of cavity observed in this series. Robinson <sup>4</sup> has called attention to yet others and has described very perfect methods of closing chronic cavities by plastic operation. Both Robinson and Beckman <sup>5</sup> have called attention to the effect of perfect drainage upon even very aged infected empyema cavities and have shown that if this step is taken as a preparation for a plastic operation the plastic operation is often unnecessary. No one, however, as far as I know, has consistently attempted to base the prognosis and treatment, in either acute or chronic empyema, upon the shape and situation of the cavity. In this series the tendency toward healing in all cases in which the lower angle of the lung is well placed in the costodiaphragmatic angle has been so consistent that at the present time a good prognosis is given under these circumstances without regard to the position of the apex. Or to put it another way, if there is available lung surface to fill out against the chest wall no plastic operation is contemplated. On the other hand, if the surface of the lung has bowed out to its fullest extent without being able to fill the gap, a plastic operation is held to be desirable. Additional experience may well modify this view, but at present it is found to be an excellent working hypothesis.

The application of this hypothesis to the operation for acute empyema is of course most important. It is impossible in most instances to determine before operation the size and shape of the empyema cavity as well as the position and degree of freedom of the lung. If then, the lung in the majority of cases is already adherent in a favorable position, no such operation as that advised by Lilienthal (rib separation by a long incision with incision and separation of the limiting fibrin membrane covering the lung) should be necessary as a routine. The operation might then be reserved until it is demonstrated, by clinical and Röntgen examination after preliminary drainage, that the lung is held in a position unfavorable to expansion.

## PROGNOSIS AND TREATMENT OF EMPYEMA

A study of operation notes and of Röntgen plates taken early after operation shows that of 26 operative cases: In 18 the lower outer angle of the lung was adherent well out in the costodiaphragmatic angle. In 1 the lung was collapsed and adherent (it was freed and recovery followed). In 4 the lung was free and expanded or free and collapsed. In 3 the relations of the lung were not noted.

It has been shown, then, in this series, that in two-thirds of the cases the lower angle was well placed and that there was ample lung surface available for expansion. These cases have made complete recoveries under simple rib resection (novocaine), and while I do not doubt that removal of the infected fibrin membrane might have hastened convalescence I should suppose that the Lilienthal operation, as carried out by most surgeons under average anæsthesia, would have led to a higher mortality (see results). Even in the hands of Lilienthal<sup>6</sup> the deaths resulting from the radical operation have totalled 27 per cent. in 44 cases as contrasted with a mortality of 16 to 18 per cent. in 45 patients upon whom a local drainage operation (with or without rib resection) alone was performed. All patients, however, who have recovered after the radical procedure have left the hospital entirely healed and without thoracic deformity, a most creditable showing.

In instances of complete collapse of the lung with adherence in unfavorable position (less than 4 per cent., or one case in this series) the Lilienthal operation should be of distinct advantage, but I can see no reason even then for making it a routine initial proceeding. Moreover, many huge empyema cavities allow at operation no clear indication of the actual position of the lung. There have been several cases (as, for instance, Case II) in this series in which the lung appeared to be completely collapsed and buried behind the usual shaggy yellow pus and fibrin coat. Yet inspection and Röntgen studies made within a week of operation showed that the lung had lain from the first flattened out upon the diaphragm, well out into the costodiaphragmatic angle, and that already it had nearly filled the chest.

I should plead, then, for more careful study of the empyema cavity before (if possible), during, and after the original drainage operation with the idea of adopting at the earliest favorable moment the particular procedure, if any, which is held to be essential to healing. Having this in mind, the original operation would properly consist in rib resection under a local anæsthetic, as the safest life-saving measure.

There follow the results of operation for acute and chronic empyema for the period January, 1913, to July, 1917.

There have been 26 cases of acute empyema. Of these, 3 died soon after operation, a mortality of 11.5 per cent.†

Of those dying after operation one showed before operation a fibrillat-

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† The number of cases here followed is too small, of course, to furnish figures of much value, even though it covers unselected cases in four years of hospital life. The truth of this statement is borne out by the much higher mortality of the streptococcus empyemata of this present winter (1917-1918).

ing heart and died the day after operation; one died some months later of gangrene of the lung though the empyema cavity was well drained and nearly obliterated; and the third, a neglected case of eight weeks' standing, died suddenly on the day following operation while making an apparently good recovery (cause of death unknown).

Of the surviving 23, 19 have been seen or heard from recently and are well (73 per cent. of all acute empyema cases).

Of the above 19, 3 have required secondary operations, but are now well.

Of the 23 who left the hospital apparently on the road to recovery, 1 is still under treatment. The other three showed granulating wounds and healed cavities when last seen in the Out-door Department, but cannot now be traced.

If the 3 untraced cases thought to be healed are included with the 19 known to be well, the percentage of complete recoveries would be 84.

There have been 8 cases of chronic empyema. Of these 1 is well. Two have died of embolism (cerebral or pulmonary). One has died of tuberculosis. Three are much improved and are able to work. One is still under treatment.

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## TREATMENT OF PENETRATING GUNSHOT WOUNDS OF THE CHEST WITH HEMORRHAGE INTO THE PLEURA\*

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HÆMOTHORAX is the most common result of a chest wound, pneumo-hæmothorax and pneumothorax are said to be very rare. Hæmothorax may be sterile, or it may be infected. Infection may occur as late as the second or third week, its onset being characterized by pain, dyspnœa, fever, etc. In a series of 450 cases observed by Bradford and Elliott,<sup>1</sup> infection was present in 117. It will readily be seen, then, that the only justification of the old conservative routine of surgical non-intervention lies in the fact that so many cases of shot wound of the chest remain uninfected.

From the third day to the third week death from hemorrhage, in the above series, was rare as a result of the chest wound. Septic infection of the hæmothorax was the most common cause of death and secondary hemorrhage was extremely rare. The bloody fluid in hæmothorax is defibrinated blood. In infected cases the pleural exudate is abundant and there are many polymorphonuclear leucocytes. Massive clotting is more common in infected cases.

In a considerable proportion of the infected war cases, there was gas formation which was usually very rapid. The gas may be free in the pleural cavity or *localized* above the fluid and below the non-collapsed portion of the lung. There is a difference of opinion as to the most frequent source of the hemorrhage in hæmothorax, though it is very probable that, in the majority of cases, the source is the injury to the lung. But there are some cases in which the bulk of the bleeding comes from an injured vessel in the chest wall.

The physical signs of hæmothorax are variable, but an important one is a high diaphragm on the affected side. The main problem in diagnosis, however, is to determine whether a hæmothorax is infected or not. Rapid pulse, pallor, sweating and collapse are common symptoms of the rapid spreading anaërobic infections. Microscopical and bacteriological examination of the fluid withdrawn will determine the presence or absence of infection. Sometimes, it is necessary to explore the chest at different levels. In sterile hæmothorax, if the amount of fluid is small, there is no need for special treatment. If the amount of fluid is large, aspiration at the end of the first week is advised. Aspiration with oxygen replacement is said to be better than simple aspiration, the patient being left with 200 to 500 c.c. of oxygen in the pleura, at a pressure somewhat above the normal pleural pressure. Free drainage is advised in all cases of infected hæmothorax. Recently the Carrel-Dakin technic has been applied with success.

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\* Read before the New York Surgical Society, March 27, 1918.

<sup>1</sup> Bradford, J. R.: Brit. Med. Jl., 1917, ii, 141.

I have to present two cases, which exemplify two different types of hæmothorax. One, with acute progressive and wellnigh fatal hemorrhage, which called for immediate operation, and another, which illustrates the so-called clotted hæmothorax with later infection, and delayed operation. The following is the report of the case of urgent hemorrhage with immediate operation which is abstracted from the *Transactions of the New York Surgical Society*, for 1903.

At a meeting of this Society on May 27, 1903, I presented a patient upon whom I had operated a month previously, April 28th, for shot wound of the right chest with severe primary hemorrhage into the pleura. He had been brought to the hospital fifteen minutes after his injury, in a condition of extreme shock. He was immediately put to bed and given a subcutaneous infusion of warm saline solution. Examination showed a contusion and abrasion about one inch long, over the right anterior superior spine of the ilium. A second bullet had passed through the upper third of the right forearm. The third bullet was embedded in the right chest, the wound of entrance being through the gladiolus of the sternum, one inch above the ensiform cartilage.

Within two hours after the patient's admission, a large hæmatoma had developed over the right side of the chest, in the region of the eighth rib. It measured 4 by 6 inches then, and slowly increased in size, its long diameter being parallel with the long axis of the ribs and its centre in the mid-axillary line. The patient complained of a feeling of oppression and difficulty in breathing. When seen by me, about two hours after his admission, he was still in a condition of some shock but the hemorrhage had apparently ceased and he was slowly improving under treatment. A little later, he vomited some blood. About four hours later his condition was such that it was deemed wise to operate.

From the situation of the wound and its direction, it seemed probable that the abdominal cavity might have been invaded and accordingly an exploratory laparotomy was done under gas-ether anæsthesia. An incision  $2\frac{1}{2}$  inches long was made in the median line 2 inches below the ensiform. There was no free blood in the peritoneal cavity, the stomach and intestines were moderately distended with gas. The cardiac end of the stomach was normal in appearance, but the pyloric end was congested. There was no perforation of stomach or intestine. This fact determined, the abdominal wound was closed and attention turned to the chest.

An incision 7 inches long was made along the eighth rib, through the large hæmatoma which had developed, and a large amount of clots liberated. Two inches of the seventh and about four inches of the eighth rib were resected in the mid-axillary region. The eighth rib had been shattered and perforated by a bullet of thirty-eight calibre. The pleural cavity was opened and a large amount of fluid blood and clots was evacuated. The hemorrhage from the hole in the lung which was inspected had apparently ceased. The lower and middle lobes of the collapsed lung could be plainly seen and felt. There was also noted an abraded area over the dome of the diaphragm, evi-

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dently made by the bullet. After washing out the cavity with hot saline solution the lower edge of the partly collapsed lung was sutured to the parietal pleura at the posterior superior margin of the operation wound and the posterior portion of the incision was closed without drainage. The anterior third of the wound was not sutured, but lightly packed with sterile gauze which did not extend into the pleural cavity. The outer dressings only were changed daily, on the three days following. They were lightly stained with an orange colored discharge. When the packing was withdrawn on the third day, the opening into the pleura was evidenced by the sucking in of air. Two days later, however, it had apparently entirely closed off by wound contraction and the lung expansion and it never reopened. The wound granulated rapidly from the bottom, the rest of the incision healing by primary union. Further recovery was uneventful except for marked abdominal distention and some vomiting during the first forty-eight hours. He was discharged as cured, May 19, 1903, twenty-one days after his injury.

The lung expansion was apparently normal and the bullet could be felt near the inner edge of the right scapula, but gave him no trouble.

The treatment of this case, fifteen years ago, in the light of recent war experience, was proper and conservative and the result certainly justified it.

*Gunshot wound of the left lung with clotted hemothorax later becoming infected. Late primary drainage—later resection and partial decortication of the lung. Recovery.*

On June 9, 1917, I saw in consultation, in a distant city, a case of gunshot wound of the left chest which had been sustained about two weeks previously. The patient, a woman about forty-two, was shot at close range by a revolver bullet which entered the front of the left chest between the second and third ribs below the middle of the clavicle, passing obliquely from above downward and backward until it lodged under the skin over the tenth dorsal vertebra, where it had been removed some days before.

The patient's condition at the time of my visit was not good, she was running an irregular temperature, between 100° and 102°, she looked very pale and had greatly embarrassed respiration and a rapid pulse. There was flatness over the whole side of the chest and the radiograph showed the entire left side of the chest to be cloudy, with all the normal lung markings obliterated. Aspiration yielded a blood-stained fluid. Her condition was not improving under conservative treatment and the question of operation was put cleanly up to the surgeon. Drainage seemed to me imperative on account of her condition and the probability of infection. The patient was unable to take a general anæsthetic on account of her oppressed breathing, and under local anæsthesia with one-half per cent. cocaine an incision was made near the posterior axillary line between the sixth and seventh ribs, and the pleura opened. A rubber tube was inserted and a large amount of bloody fluid with a slightly perceptible odor but no clots was evacuated. The

little operation, which was regarded as merely a preliminary to a later and wider drainage, gave great relief. The patient was left in the hands of her physician and not seen again until after the lapse of twelve days. At the second visit, the attending physician reported considerable relief from the operation, but the elevated temperature still persisted and the drainage was not satisfactory, the tube being evidently blocked by clots. As the patient's condition had been much improved by the relief of pressure on the lung, it was deemed safe at this time to give a general anæsthetic. Accordingly, under gas-ether anæsthesia, the incision was extended backward and a portion of the seventh and eighth ribs removed and a reasonably wide opening into the pleura made. The cavity was found filled with soft clots which were washed out with warm saline solution. There was no fresh bleeding and, as there was no gross pus present, the wound was partly closed and drainage provided by loose sterile gauze packing in the wound. Much relief to breathing followed this operation and the patient was left in good condition. Following this the patient improved, but the drainage was still not satisfactory, so that a tube had to be inserted, and this would become obstructed from time to time with clots. Accordingly, about one week later, June 28th, the patient was sent to New York and placed under my care at the Roosevelt Hospital.

The wound was dressed soon after her arrival at the hospital and the discharge was free and purulent. She had stood the long journey well. Her temperature still remained elevated and she appeared distinctly septic. She was dressed daily, and about July 1st a long tube was inserted and the chest was washed out with saline solution, which seemed to improve the condition very much, as her temperature fell and she was able in a day or two to get up in a chair and to use the blow bottle to improve the expansion of the lung. During the following few days large fibrinous clots were washed out from time to time, always with relief, so that the temperature gradually fell to about normal and the discharge decreased and became somewhat thinner and the lung expansion continued to improve. By July 21st the drainage opening had so constricted that unless a long tube were used so as to pass above the arch of the diaphragm, it was ineffectual. By August 1st the temperature remained flat for five days and the discharge was thinner and much reduced in amount. Washing out occasionally through a larger tube was done, but the clots seem mostly to have disappeared. On August 6th the drain tube was left out experimentally for a test. Temperature remained flat for four days, the wound granulated in, and there was no discharge. Then there began to be slight rise, a little headache and sleepiness and finally, on August 11th, there was a rise of temperature to 102° and during the night the wound broke open and flooded the bed with pus. The drainage tube was then reinserted and the exercises with the blow bottle continued. The patient's general condition was all the time improving and she got up and moved about the hospital. On August 20th the chest cavity was injected with barium mixture through the drainage sinus and a radiograph was made to show the extent and limits of the space. Con-

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siderable reaction followed, as the barium obstructed the drainage more or less for several days and had to be washed out. The limits of the empyema cavity as shown by X-ray extended from the fourth to the ninth rib.

For several days in the latter part of August, the discharge was quite thin and the tube would be left out for a day or two and then reinserted. By September 3rd, the expansion had so far improved under the exercise of the blow bottle that the patient felt quite encouraged. By the middle of September the discharge was thin, but any attempt to allow healing was followed by retention.

It seemed necessary, therefore, to resort to further operative measures if the space were to be obliterated and the adherent lung freed.

On September 20th the patient was taken to the operating room for the third time and, after the usual preparation and under gas-ether anæsthesia, the original incision over the eighth rib was extended laterally and a long vertical incision was made from its posterior extremity upward behind the scapula through the muscles, allowing the scapula to be well retracted and the field well exposed. The lower ribs, eighth and ninth, were resected to the extent of several inches, and through this opening the length, shape, and height of the cavity was determined. The cavity was found to be a triangular-pyramidal space extending upward and backward and narrowing as it went up and terminating behind the fourth rib and extending downward to the level of the tenth rib, gradually broadening out toward the base. The lung covered with much thickened pleura was adherent to the parietal pleura at the lateral boundaries of the cavity. A short section of the fourth rib was resected and gradually longer pieces of the lower ribs until the ninth was reached, which was excised up to the limits of the base of the cavity. The thickened parietal pleura was also excised, which gave a perfect exposure of the surface of the lung to be decorticated. The pleura covering the bound-down portion of the lung was then incised and flaps turned back by blunt dissection, which allowed the lung to expand and fill the space. This step of the operation was materially helped by converting the anæsthesia apparatus into a positive pressure machine which blew out the lung nicely. After the broad decortication, the hemorrhage, which was not excessive, was controlled, and the edges of the incision brought together by layer sutures. As the lower end of the wound had been the site of the old sinus it was not possible to thoroughly disinfect it. This part of the wound was not closed by suture, but the edges came fairly well together after the old granulations had been thoroughly curetted away. At the close of the operation the lung was once more blown up by positive pressure and the remaining open end of the wound was covered with a piece of sterile adhesive plaster and the dressing applied.

The operation was long and difficult, but the patient bore it well and showed only moderate shock at the closure. She soon rallied, and, after the first forty-eight hours, gave us no anxiety.

The wound became infected both at the lower and upper end, but the removal of a few sutures and release of tension was followed by

healing throughout its greater part by primary union. Drainage had to be instituted for several days at the lower angle on account of retention of bloody fluid and, later, of pus. But the wound after several weeks healed satisfactorily throughout and the sinus has remained completely closed. Good lung expansion has been obtained and the patient is happily at work and free from symptoms.

The final result, obtained after many weeks, has been very satisfactory to both patient and surgeon and corresponds in large degree with similar results obtained in several cases of empyema from other causes in which decortication of the lung has been followed by satisfactory expansion and complete closure of the sinus. Had it been possible at the primary operation to have secured through a more extensive incision thorough evacuation of all the clots, the history of the case might have been different, but the conditions were not favorable to such a procedure.

With the progress of the great war the history of the surgical treatment of penetrating wounds of the chest is being largely rewritten and an examination of the literature of the subject shows a marked tendency toward radical early operative interference in selected cases based upon the modern method of wound prophylaxis against infection, performed at the earliest possible hour and followed in appropriate cases by closure of the wound.

A brief résumé of some of the work that has been done in the service of the British and French armies during the past two years is added. The literature already large is constantly growing and is of the greatest importance and interest.

In an analysis of 170 cases of chest wounds seen by him at a base hospital in France during the first two years of the war, ELLIOTT<sup>1</sup> groups them as follows:

1. Sterile hæmothorax, 89. 2. Septic effusion, 64. 3. Clotted hæmothorax later septic, 3. 4. Sterile pneumothorax, 6. 5. Severe laceration of the lung, 2. 6. No effusion, 6.

The chief practical points of this valuable paper, as summarized elsewhere, are, first, that a sterile hæmothorax of moderate extent, *i.e.*, about thirty ounces, will recover as rapidly by natural absorption as by aspiration.

Second, the retention of foreign bodies in the chest in aseptic cases appears not to cripple the bearer for further military service.

Third, cases of infected hæmothorax that have been drained and then transferred to England generally recover rapidly and completely. There were no deaths in these cases and later operation was rarely needed. Of these more than one-half could return to duty.

Fourth, the late mortality of chest wounds is practically *nil* in England, and only about 5 per cent. in the lines of communication in France. But in the region of the armies it is higher than at first supposed—that is to say, about 10 per cent. to 15 per cent. may die from the severity of the injury, and about 10 per cent. later at the casualty clearing stations from sepsis.

Fifth, among the cases which develop sepsis within the chest the mortality is very high, rising to nearly 50 per cent. by the old system of rib resection and drainage.

<sup>1</sup> Lancet, Lond., 1917, 193, p. 371.

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Sixth, the old conservative routine of surgical non-intervention except by late drainage finds its justification only in the recovery of those cases of gunshot wounds of the chest which remain non-infected, about 75 per cent. The high mortality in those which develop sepsis demands a wider practice of new prophylactic method of cleansing operations performed at an early hour in a carefully chosen group of cases.

COMBIER and HERTZ,<sup>3</sup> in a recent paper on the "Early Treatment of Septic Pleural Effusions Consecutive to Chest Wounds," advise non-interference in wounds showing neither fracture nor effusion. If there is fracture of the rib or scapula they reduce the fracture and close. A small foreign body is left. If of considerable size, and easily accessible, it is extracted immediately. In other cases secondary extraction is preferred. If there is pleural effusion which examination shows to be septic, a low incision is made, under local anæsthesia, in the posterior axillary line, and a portion of the ninth rib resected. Foreign bodies in the affected area are extracted. The pleura is then disinfected by means of an intermittent irrigation of Dakin's fluid.

Of 15 cases so treated, 12 recovered, 11 from pleural abscesses, and 1 from a subphrenic abscess. In 3 cases there was a later reinfection of the operative wound which had to be redisinfecting and closed; complete recovery. They advise great prudence in deciding upon the time of suture, for it is always necessary to wait until 2 or 3 successive examinations of the wound show the permanency of its disinfection before closing.

Radioscopy in recovered chronic cases shows the costophrenic angle adherent and immobile, the diaphragm being raised even in forced expiration, showing that the lung does not penetrate the costophrenic sinus. In early operated cases, however, the thorax preserves its form and almost normal limits, and radioscopy shows a normal permeability of the lung tissue which shows that the value of the recovery appears to be very much greater in cases where early operation is done.

V. PAUCHET<sup>4</sup> says that 30 per cent. with chest wounds die at the first aid stations of asphyxia or hemorrhage and 20 per cent. in the ambulance, and a few later in the interior. If those that die on the field are added it can be said that the majority of chest wounds in this war are fatal. He divides the treatment into: (1) the immediate, and (2) late, the first indication being to combat shock—infusion, transfusion, etc. Open wounds often call for immediate intervention; closed wounds for rest and watching. In open wounds he removes the fractured rib, cleans out the wound, removing the projectile if easily found.

A. L. LOCKWOOD and J. A. NIXON,<sup>5</sup> in an article entitled "Treatment of Septic Hæmothorax and Empyema," sum up their experience as follows:

Explore the wound under general anæsthesia, fractured portions of rib to be resected, and wound sewn up if the condition allows. The pleural cavity is then drained in the usual fashion, resecting about 3½ inches of rib as far forward and as low as possible; that is, generally the eighth rib in mid-axillary or anterior axillary line. Through this opening explore the cavity, remove an easily accessible foreign body from cavity or surface of the lung. Blood clots and fibrin should be swabbed off as fast as possible, and any septa-forming loculi should be broken down. The cavity is next washed out with a warm mixture of H<sub>2</sub>O, and eusol or Dakin's fluid. A large rubber with a ¼-inch inside diameter and with a large lateral opening ¼-inch from the end is so inserted that the end lies in the lowest part of the pleural sac costovertebral recess. The wound is loosely closed, no attempt being made to secure air-tight closure around the tube.

When the patient has recovered the size of the cavity is estimated by filling it carefully, but generally incompletely, with Dakin's fluid, and then emptying it. After

<sup>3</sup> Bull. et mém. Soc. de chir., 1917, liii, p. 678.

<sup>4</sup> Presse Méd., 1917.

<sup>5</sup> British Medical Journal, February 2, 1918.

this, about every four hours, it is filled to about  $\frac{1}{3}$  capacity; then, after two hours, another long tube is attached to the tube in the chest and siphoned off, the patient meanwhile lying upon his sound side with the drain uppermost. He is instructed to pant or cough lightly so as to bathe all parts with the Dakin's fluid. In this way, every two hours, the cavity contains considerable fluid and then is empty for two hours. While full the patient lies on his sound side without raising his shoulders, so as to prevent the escape of fluid. Later he lies on the injured side. The tube is removed and sterilized once daily, and the cavity is washed out. The principles underlying operation in these cases are: excision of the wounds in the chest wall, wiping out of the pleural cavity if the lung has collapsed, and hæmothorax is present. Search for foreign bodies and remove the fragments if practical, finally, to close the wound completely. The aim of the operation is prophylaxis against sepsis, if it fails secondary drainage may be necessary.

J. E. ROBERTS and J. G. CRAIG<sup>\*</sup> report 199 cases. Of these 108 were evacuated without operation, 124 died without operation, 67 were operated upon. Of these 67 apparently forlorn hopes, 34 recovered and were sent to the base. Of the 33 fatal cases, 16 had other gross lesions which were more directly responsible for their death than the operation. Excluding these, the rate of mortality in the 51 remaining cases was  $33\frac{1}{3}$  per cent. recoveries. The principles followed involved early operation, free excision of infected tissues, removal of the foreign body, and cleaning the pleural cavity and wound of the lung, followed, when possible, by accurate suture without drainage. No cases were drained unless the chest wall could not be closed, owing to the condition of the patient, or in cases where infection of the lung and pleura as distinguished from the contents could be definitely established.

The most frequent cause of death in chest cases with no other injuries was septic bronchopneumonia of the uninjured lung.

Duval urges immediate operation in severe primary hemorrhage in penetrating chest wounds. Hartmann remains skeptical, finding from inquiry at several ambulances where thoracotomy is not done the mortality varies from 12.7 to 18 per cent., which is the same as Duval reports with operation. However, in Hartmann's cases no report is given of cases dying from hemorrhage.

Duval in the discussion brought forward some additional cases to those included in his first report, making his mortality 32.1 per cent., with recoveries in 67.9 per cent., and he reiterates his opinion that in all severe hemorrhages thoracotomy with suture of the lung saves two-thirds of the patients.

J. ANDERSON<sup>†</sup> classifies his severe cases into two groups from the point of view of prognosis: 1. Entrance and exit bullet wounds, and wounds caused by small fragments of high explosive-missiles. These cases do well with expectant treatment and may be aspirated or operated as occasion arises. 2. Wounds caused by large irregular fragments of high explosive shell which has lodged in the thorax and almost always associated with carried-in portions of clothing and infection, and open "sucking wounds" of the chest wall. If these cases are treated expectantly only a small percentage ever reach the base hospital and many of those which do die of wound complications. In this group also he includes tangential wounds of the thorax which enfilade the ribs and drive portions of bone into the pleura and lungs and those entrance and exit wounds in which the exit wound is "explosive" in character. The prognosis in these is usually not so severe, but an unduly large number develop infection unless the chest wall is treated energetically. Cases of the second group have generally died at the Casualty Clearing Stations of sepsis and exhaustion. Many could probably be saved by immediate operation on the lines adopted for other wounds.

<sup>\*</sup>Brit. Med., 1917, "Surgical Treatment of Severe War Wounds of the Chest."

<sup>†</sup>Brit. Med., 1917, "Surgical Treatment of Severe Penetrating Wounds of the Chest at a Casualty Clearing Station."



## THE RELATION OF GASTRIC ULCER TO CANCER

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THE relation of peptic ulcer to cancer of the stomach is a matter of first importance in the pathology of this organ, and, since gastric cancer is the most frequent form of malignant disease, it is a matter of considerable economic importance. If a high proportion of peptic ulcers, 50 per cent., become transferred into cancer, then the excision of two gastric ulcers prevents the development of one cancer, which is practically a fatal condition. Moreover, if gastric ulcer is a strongly predisposing condition to cancer, since it usually gives pronounced symptoms before reaching an inoperable stage of malignant change, ulcerocancer is the only type of gastric carcinoma which offers a favorable prognosis. On the other hand, if ulcers seldom result in cancer, it is unwise to spread the belief that by excising ulcers we are seriously attacking the problem of gastric carcinoma.

On the relation of ulcer to cancer, there are the widest variations of opinion. Rokitsky, in 1840, recognized that cancer might develop from ulcer. Dietrich, 1848, among 160 cancers found 6 developing near ulcers, and two in which the carcinoma was limited to portions of ulcers. Lebert, 1878, calculated that 9 per cent. of cancers arise from ulcers, while Zenker, 1882, went so far as to say that all gastric cancers are secondary to some form of ulceration. In 1890, Hauser described five cases of cancer of characteristic anatomical form following ulcer and at the same time 33 cases of other types. He pointed out the frequent persistence of free HCl in these cases. G. Futterer, 1902, concluded that ulcers in the pyloric region frequently give rise to cancer, especially in those portions of the ulcer most exposed to irritation. Mayo-Robson is quoted as finding a history suggestive of ulcer in 59.3 per cent. of his cases of gastric cancer, but he reports (1904) only one case in which a carcinomatous change in an ulcer was actually demonstrated. Payr distinguishes between simple and callous ulcers and by serial sections finds cancerous changes in 26 per cent. of the latter. Kuttner found them by serial sections in 40 per cent. of 30 cases. The Mayo clinic reports that 71 per cent. of their gastric cancers were associated with ulcer, and 68 per cent. of ulcers were complicated by carcinoma.

On the other hand, more recently, Kuttner expresses himself in quite a different way, stating explicitly that "transformation of ulcer into cancer we have not observed." The majority of callous ulcers he regards as originally cancerous and says that only exact pathological study can determine this question. Duplant (1898) described eight supposed cancerous ulcers and concluded that they were all originally cancers. He supported with numerous arguments the view that all previous cases of ulcerocancer were

misinterpreted, and concludes that cancer never develops on peptic ulcer. Hirschfeld places the proportion of ulcers that become cancerous at 5 to 6 per cent., and he summarizes clinical and statistical data indicating that the proportion is small. Among 500 ulcers reported by Stall, Greenfeld and Berthold, only 13 showed cancer and in three of these the cancer was not connected with the ulcer. Boekelmann collects a series of estimates varying from 3 to 50 per cent.

From the surgical side, the following proportions of cancerous transformation of ulcers are reported: Rubritius, 8 per cent.; Mayer, 1.9 per cent.; Busch, 2 per cent.; Spriggs, 2.1 per cent.; Bamberger, 2 per cent. in 1589 cases; Drummond, none in 72 cases long observed. Borrmann reports that among 63 gastric resections by Mikulicz for cancer none showed an origin from ulcer. In France opinions are widely at variance. Moutier in 35 cases from operation and autopsy found 19 simple ulcers, 15 distinctly cancerous, and 1 cancerous duodenal ulcer.

Thus, among acceptable authorities it is possible to choose between 2 and 68 per cent. of ulcers becoming cancerous, and between none and 71 per cent. as representing the proportion of gastric cancers that arise from ulcers. It is therefore evident that the criteria upon which one may assert that an ulcer is cancerous or that a cancer has arisen from peptic ulcer have never been clearly established or have not been respected.

It is the object of this paper to offer a contribution in this direction.

The evidence bearing on the relation of cancer to ulcer may be derived from several sources: statistical, clinical, gross anatomical, and microscopical.

*Statistical.*—The statistical evidence relates to the sex and age of the patient with simple ulcer and cancer, to the locations of the lesions, to the fate of ulcers under treatment, and to the occurrence of healed ulcers.

Hirschfeld has shown that in Berlin and Hamburg, ulcer is more than twice as frequent as in Zurich, Munich and Vienna (7 per cent. *vs.* 3 per cent.) while gastric cancer is rather less common. Yet autopsies show the same rates for gastric cancer in both Berlin and Vienna (3.3 to 3.5 per cent.). Gastric ulcer may have been a more popular diagnosis in the Berlin hospitals than in Vienna. These comparisons do not appear to be very impressive. Gastric ulcer in these cities was about four times as frequent in women as in men, but gastric cancer about equally or more frequent in men.

Williams finds in England a cancer mortality from gastric cancer among males of 21.4 per cent., females 13.2 per cent., but he found 60 gastric ulcers among 32,505 male patients and 117 among 28,175 females. The sex divergence is therefore rather striking. Bulstrode reports that in the London Hospital 402 cases of gastric ulcer were in females, 98 in males. Fiedler in 2200 bodies found ulcers or scars in 20 per cent. of female, 1.5 per cent. of male bodies. On the other hand, not a few recent observers have found ulcer quite as frequent in men as in women. Since the older view was rather substantially supported, one must conclude that some recent observers have encountered a selected material, or that they have not carefully

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excluded ulcerating cancers, or else that the proportions have actually changed. It seems at present difficult to state whether there is a great preponderance of ulcers in women.

Half the gastric ulcers occur between the ages of twenty and thirty years, and nearly all before thirty-eight, while most cancers occur in the decade of fifty to sixty years (Williams). Yet the age incidence is not always so uniform. Riegel shows that the maximum frequency for ulcers is between twenty and thirty years for women (62 cases), and between forty and fifty for men (36 cases), while isolated cases occur in advanced years. Greenough and Joslin in 187 cases found gastric ulcer five times as often in females as in males. The average in men was thirty-seven years, in women twenty-seven years. Yet Hauser's 5 cancers which were rather clear sequels of ulcer occurred between the years fifty-five and eighty-three. It is possible that the transformation of ulcer into cancer is limited chiefly to subjects well advanced in years.

The seats of election of cancer and ulcer do not favor the frequent origin of one from the other. The commonest seat of ulcer is the lesser curvature (36.3 per cent., Welch, Fenwick), whereas only 12 per cent. of cancers occur in this situation (Brinton, Welch). The commonest seat of gastric cancer is the pylorus, 60 per cent. of 4574 cases collected by Williams occurring there, while only 12 per cent. of Welch's 793 cases of gastric ulcer were thus located.

Williams regards the statistical evidence as incompatible with the frequent origin of cancer from ulcer, but it does not preclude the possibility that it occurs in a considerable number of cases. The theory of the cancerous transformation of peptic ulcer would be more acceptable if there were parallels in other organs, but in the lip, tongue, tonsil, œsophagus, rectum, larynx, cervix uteri, and in X-ray dermatitis there is first carcinoma and then ulceration. In the few instances where carcinoma follows ulcer, the malignant process develops as a rule only after many years, as in varicose ulcers of the leg. Lupus carcinoma never appears before the fifth and usually toward the thirtieth year of the disease and in the scar tissue. The cervical erosion is often associated with carcinoma, but these lesions are not originally ulcers, but rather extrusions of the mucosa which are long the seat of irritation and glandular overgrowth. On the other hand, the peptic ulcer is an exceptional condition and may be followed by exceptional results.

*Clinical Evidence.*—Since the development of cancer in a peptic ulcer must require considerable time, a history of gastric ulcer should be available in all cases so interpreted. Although gastric ulcer may occasionally fail to give symptoms, this situation must be extremely rare in any long continued case, and so long as the question is open to debate it would seem that no case should be accepted as an ulcerocarcinoma unless a long history of peptic ulcer is provided. The gastric ulcers that fail to give symptoms and furnish the healed scars found at autopsy are usually small or superficial. Latent cases of fully developed peptic ulcer are very rare.

Mayo-Robson is said to have found a history suggestive of ulcer in 60 per cent. of his cases of cancer, but suggestive symptoms are not sufficient. More convincing is the very definite report of pain, vomiting, and hæmatemesis of ten years' duration in one of Hauser's cases. Bamberger reports a history of recurrent ulcer for thirty-two years before death from ulcerocancer, and Mayo-Robson one of twenty-one years' duration. Greenough and Joslin observed a characteristic history of ulcer for two years before death from a secondary cancer. Riegel states that he is able to recognize clinically the cases of ulcerocarcinoma. They first show a long period of hyperacidity and symptoms of ulcer, then a tumor appears, the cachexia changes, and free acid diminishes or disappears. Hauser claimed that the long persistence of free HCl indicated an origin of the cancer from ulcer, but this feature is not invariable. Lockwood found a history of ulcer suggestive in 7 per cent., definite in 3 per cent., of 174 cases of gastric cancer.

An important phase of the clinical evidence relates to the fate of ulcers long observed and treated, which shows that while ulcer is permanently cured by medical measures in only about 40 per cent., it very rarely develops into cancer while under observation. Greenough and Joslin followed for five years 114 cases of ulcer treated medically. Of these 41 recurred, 27 died, 4 from unknown causes, but only 1 from the subsequent development of cancer. Hemmeter, who is one of the few authors who have adequately considered the complexities of the diagnosis, observed only three cases of cancer developing in the course of 232 peptic ulcers.

The results of gastro-enterostomy for ulcer reveal a small percentage of recurrences in the form of carcinoma (Galpern Lit.). In 1025 gastro-enterostomies for ulcer, traced for some time, Bamberg collected 22 cases developing cancer, 2.1 per cent. In 152 ulcers treated by resection, cancer developed in 1.9 per cent. Since the carcinoma usually developed within two years of the gastro-enterostomy, there is some reason to assume that some of the ulcers were originally cancerous. Gressot from an elaborate study of the literature concludes that ulcers become cancerous in 2.3 per cent. of cases treated by gastro-enterostomy. Billeter observed the course of 116 cases of ulcer treated by gastro-enterostomy. Eighty-seven patients were well after four to twenty-six years and only one developed cancer. Von Eiselsberg reports that of 269 cases of ulcer treated by gastro-enterostomy, 13 died from cancer (5 per cent.), while among 41 cases in which the ulcer was excised 2 died from cancer (also 5 per cent.). Sherren saw no cases develop cancer among 200 gastro-enterostomies for ulcer.

From the clinical evidence it may be concluded that a great number of ulcers have been treated medically for some years without developing cancer, that among the many ulcers so treated which persist or recur not more than 2 per cent. develop cancer and some of these may have been originally cancerous; that the number of cases developing cancer from ulcer after gastro-enterostomy is not appreciably larger than after resection of the ulcer; that a diagnosis of cancer following ulcer to be acceptable should carry

with it a previous history of ulcer; that this history covers a period of ten to thirty years in certain well attested cases, while in less satisfactory but possibly genuine cases the history of ulcer covers only two years.

*Gross Anatomy.*—The gross anatomy of cancer engrafted upon ulcer is usually characteristic, and hence if the case is to be accepted as such, this characteristic appearance should be demanded. On the other hand, it has repeatedly been shown that grossly typical peptic ulcers may form on a mucosa which is the seat of carcinoma. Failure to realize this fact has often led to the excision of ulcers under the impression that they were benign. A microscopic study in every case is called for.

Hauser clearly depicts the rather specific appearance of cancer grafted upon ulcer (Fig. 1). The deep, sharply cut excavation, overhanging proximal edge, firm fibrous base, and often the extension of the cicatrix to surrounding organs are satisfactory evidences of the long existence of a typical peptic ulcer. The carcinoma has usually appeared at one or more points, usually distal, sometimes becoming fused, and causing induration and fixation of the edge. Outlying islands of polypoid adenoma or adenocarcinoma are not infrequently observed. Menetrier states that carcinoma develops on ulcer only after a preliminary stage of polypoid adenomatoid growth.

The necessity of insisting upon a dense indurated base free from cancer seems to me essential. A. Schmidt finds it impossible to conceive how large flat ulcers, 3 to 4 cm. in diameter with extensive cancerous infiltration of the periphery, can be derived from the malignant transformation of an ulcer. The opposite relation seems to him more probable.

That an original cancer may be stripped of epithelial tissue over a central area and the base converted into dense cicatricial tissue resembling peptic ulcer is shown by Verse, in the report of his case No. 34.

The early stages of many carcinomas of the stomach reveal the important rôle of ulceration in the course of these lesions. Verse has described 12 very early carcinomas of the stomach. They consisted of circumscribed thickenings of the mucosa, 1 to 2 cm. in diameter, in which the glands presented the changes of adenocarcinoma or fully developed carcinoma. In some, the surface was unbroken, but the stroma was infiltrated by polynuclear leucocytes. I have studied such a lesion covering an area of 2 cm. in the cardiac region. Usually ulceration had become established with more or less complete excavation of the central portion. These early and rarely observed lesions reveal the close connection between ulceration and cancerous proliferation in carcinoma of the stomach and they emphasize the necessity of great caution in assuming that an ulcerating and carcinomatous process is anything else than an ulcerating cancer. Especially in the pyloric region where mechanical erosion is constantly at work, early and sometimes deep ulceration may be expected as a natural sequence in the growth of carcinoma.

In certain cases of peptic ulcer followed by carcinoma the latter process has appeared to be disconnected from the former (Hauser, Verse, Galpern). This occurrence has been sufficiently frequent, as after excision of ulcers,

to lead to the conclusion that when carcinoma does follow ulcer the relation may be accidental. Galpern and Bamberger state that the stomach with peptic ulcer is as likely to become cancerous as the normal stomach and no more. Yet this conclusion ignores the undoubted development of cancer in the inflamed edges of certain ulcers.

From the anatomical data one may conclude that the gross appearance of cancer grafted on ulcer is usually characteristic; that this evidence is the most direct and convincing in regard to the relation of the two processes and should be demanded in acceptable cases; that ulcerating cancers may closely simulate peptic ulcers with secondary malignant changes; and that cancer and ulcer may occur independently in the same stomach.

*Microscopical Evidence.*—The development of carcinoma in the edges of chronic ulcers has been minutely described by Hauser, Verse, Menetrier, Wilson and McCarthy and others. In this field it is necessary to emphasize the difficulty of recognizing all the structural variations which carcinoma may exhibit. When one compares the fading remnants of carcinoma cells in the leather-bottle stomach (linitis plastica) with the bulky masses of adenocarcinoma, and contrasts these in turn with the diffuse round-cell carcinomas and the curious forms arising in wide areas of glands with intact membrana propria, one realizes that in carcinoma of the stomach there are unusual hazards in histological diagnosis. Perhaps the active movements of the pyloric antrum account for some of these structural peculiarities. When such an experienced observer as Krompecher, after years of study of pyloric stenosis, is forced to change his opinion and to accept these lesions as carcinomas which he had long failed to recognize, it becomes apparent that this is no field for hasty interpretation.

In Hauser's cases the edges of the ulcers were markedly hypertrophic, the carcinomatous changes were most marked at the line of ulceration and extended with diminishing intensity for a distance of  $\frac{1}{2}$  to 1 cm. over the outlying mucosa, the infiltration involved the peripheral submucosa and the muscularis, while the indurated base of the ulcer was free from infiltration. The various stages of transformation of the normal into carcinomatous glands were traced in detail, ending usually in an adenocarcinomatous structure. Lesions presenting these features and this series of changes in portions only of the edges of indurated ulcers must be accepted as satisfactory examples of the development of carcinoma on peptic ulcer. I do not find, however, that all authors have observed these criteria in the diagnosis of ulcerocarcinoma. Verse describes three typical cases and then ventures with some hesitation to include a fourth, a broad ulcer in a woman of twenty-eight years in which projecting islands of carcinoma of rather diffuse type occurred over the base of the ulcer. I cannot regard this lesion as anything else than an ulcerating cancer. It would seem extremely unlikely that a secondary carcinoma can ever invade the indurated base of a peptic ulcer. These tissues are usually very dense and fibrous and when they are invaded by carcinoma it would be much safer to assume that the infiltration existed before the ulceration.

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McCarthy evidently includes among the evidences of carcinoma a variety of inflammatory hyperplasias and misplacements of gastric glands some of which result from inflammation about the ulcer and at other times probably precede the formation of the ulcer. These changes may well be grouped in the class of precancerous processes. Yet it is one of the dangers of the dissemination of the doctrine of precancerous lesions that their presence may too readily be assumed to mean that carcinoma already exists or soon will appear, whereas there can be no certainty that any given precancerous lesion would, if undisturbed, go on to develop cancer. In the case of gastric ulcers Galpern's and Bamberger's observations on the fate of gastric ulcer after gastro-enterostomy seem to prove that these lesions seldom go on to produce cancer.

In my own material I have had much difficulty in deciding how to interpret some ulcerating and cancerous lesions. Certain conclusions, however, have been drawn from the study of material from autopsy and operation which bear upon the relation of cancer to ulcer.

(1) The great majority of ulcerating lesions of the stomach fall clearly in the classes of ulcerating cancers or simple peptic ulcers. The cancers are usually broad, widely and uniformly infiltrating, and the ulceration is merely an erosion or an irregular excavation beginning in the centre and extending over much of the surface. Pyloric cancers are especially prone to suffer excavation. The peptic ulcers are sharply cut, the edges flat but overhanging, the base is indurated and free from any signs of cancer. The surrounding mucosa shows much or little glandular overgrowth. This material does not support the view that peptic ulcer tends strongly to atypical glandular proliferation.

(2) With certain peptic ulcers a large part of the gastric mucosa is the seat of glandular hypertrophy with atypical changes in isolated glands and interstitial growth of connective tissue which causes some disarrangement of the glands. This condition is not secondary to the ulcer but may well predispose to ulcer. It may serve as a source of error in interpreting atypical overgrowth on the edges of ulcers (5584, 5715) (Fig. 2).

(3) Deep excavations may occur in portions of established carcinoma especially in the pyloric region where powerful muscular contractions tend to cause hernias of infiltrated and weakened muscular tissue. This condition appears clearly in three of my cases. In case 5296 the entire pyloric region for a length of 6 cm. is the seat of a broad, dense carcinoma of uniform texture. It is considerably excavated and at a point 2 cm. from pylorus the excavation descends abruptly in a cavity  $\frac{1}{2}$  cm. deep which lies upon pancreas. All portions of the ulcer, edges, base, and adjoining pancreas are uniformly infiltrated with large alveolar adenocarcinoma. Some would interpret this case as carcinoma grafted upon ulcer, but I am unable to conceive how carcinoma could have infiltrated so uniformly all portions of the base of this lesion if it arose on the edges of an ulcer and had to attack old dense connective tissue. This same type of adenocarcinoma covered the

mucosa uniformly for a distance of 3 cm. about the ulcer. There was no history of an old ulcer (Fig. 3).

In case 5099, a very similar gross lesion with deep central excavation proved to be a rapidly growing diffuse round-cell carcinoma. The tumor cells infiltrated the entire base of the ulcer, splitting up the muscular coat and invading the subserous fat and the pyloric lymph-nodes. This type of carcinoma is not readily derived from atypical proliferation on the edges of an ulcer (Fig. 4).

Case 8253, placed at my disposal by Doctor Elser of New York Hospital, is highly instructive, illustrating the formation of peptic ulcers on a diffuse carcinoma of the stomach. The patient, a male, fifty years, moderately alcoholic, enjoyed good health until four months before death, when he began to suffer from gastric disturbance soon followed by sharp pains after eating. He died after laparotomy. At autopsy there was extensive miliary carcinosis of peritoneum. The whole pyloric region of stomach showed moderate thickening of mucosa increasing toward the pyloric orifice, and this region was irregularly adherent. There were three typical peptic ulcers. One was a slit-like excavation at the pyloric orifice looking into the duodenum. The others lay on posterior surface 6 and 9 cm. from the pylorus. They measure  $1\frac{1}{2}$  cm. in long diameter, edges overhanging but not indurated, bases cleanly excavated and smooth, extending into muscularis. On microscopical examination the entire pyloric region was the seat of diffuse carcinoma infiltrating all coats. The bases of the ulcers were formed throughout by carcinoma tissue infiltrating the muscle. The remnants of glands on the edges showed no change (Figs. 5 and 6).

(4) Gastric digestion may strip a primary carcinoma down to the muscularis or deeper, leaving no trace of carcinoma over most of the base but only a peripheral ring of tumor tissue which is protected by the mucosa. This event is indicated in some of Verse's cases which ulcerated early and it appears in one of mine.

This case, 5397, presented the usual appearance of peptic ulcer of rather broad dimensions and was excised as such and at first passed the laboratory as simple ulcer. On section it was found that the entire ulcer was surrounded by a continuous narrow ring of carcinoma partly protected by the intact mucosa (Fig. 7). Glandular proliferation of the peripheral mucosa was missing, the tumor ending abruptly. The structural type was that observed in many early carcinomas, strongly atypical small alveolar adenocarcinoma. The lymph-nodes were not involved. The central two-thirds of the base was free from carcinoma. Wilensky and Thalhimer seem to have encountered a notable case in which all traces of an original carcinoma were completely excavated, leaving a simple peptic ulcer in the stomach wall, while the adjoining lymph-nodes were the seat of carcinoma.

(5) When the base of an ulcer is uniformly infiltrated with carcinoma, especially of diffuse or atypical small alveolar type, the condition is difficult to reconcile with an origin from the edges of the ulcer (Fig. 8). When





FIG. 1.—Hauser's drawing showing the gross anatomy of carcinoma grafted upon ulcer. Note the polypoid projections and the irregular distribution of the opaque carcinomatous tissue.

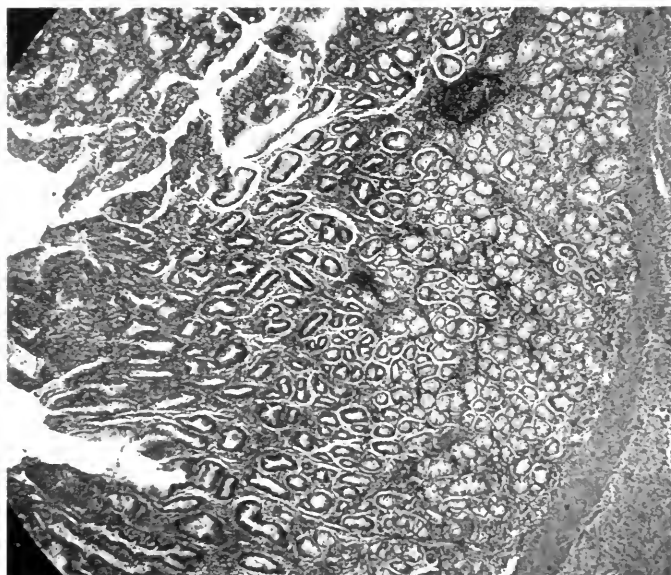


FIG. 2.—Atypical changes in glands in diffuse hypertrophic gastritis involving most of the mucous membrane in a case of peptic ulcer. The hypertrophy is not a result of the ulcer.

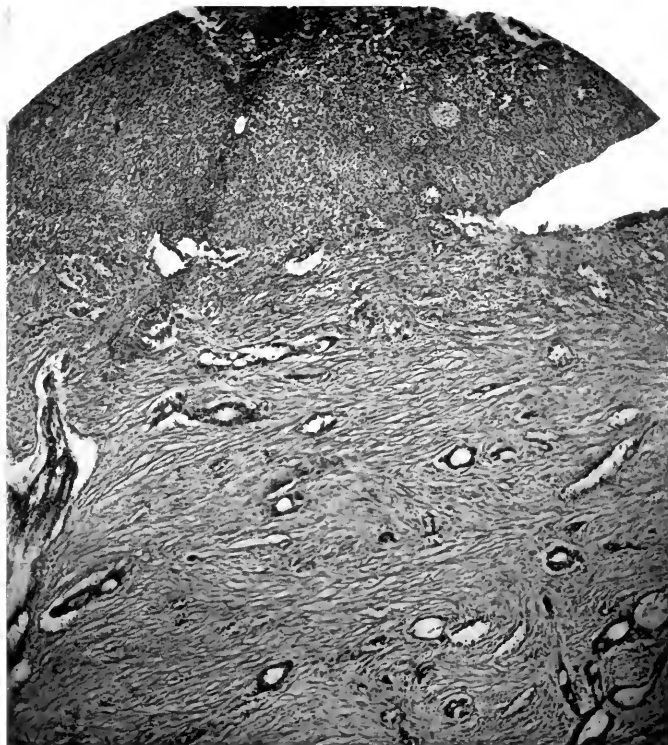


FIG. 3.—Case 5296. Fibrosing adenocarcinoma involving 6 cm. of the pyloric region. The section comes from the edge and base of a deep ulcer reaching almost to pancreas.



FIG. 4.—Case 5099. Inflammatory changes in the mucosa on the edge of a peptic ulcer grafted on diffuse round-cell carcinoma of pylorus. The carcinomatous process is invisible in this magnification.



FIG. 5.—Case 8253. Multiple peptic ulcers grafted upon diffuse carcinoma of pyloric region.

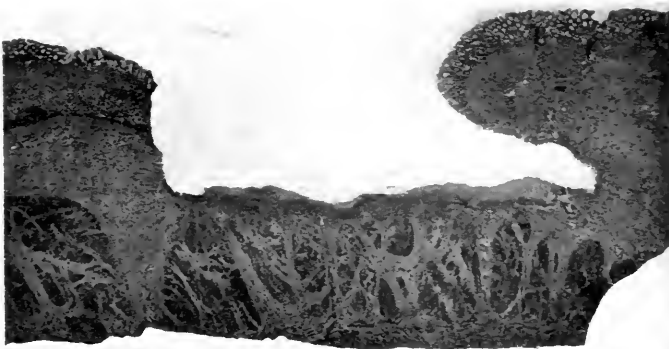


FIG. 6.—Cross-section of one of the ulcers in Case 8253. The muscularis is split up by diffuse carcinoma. The glands in the overhanging edges are unchanged.

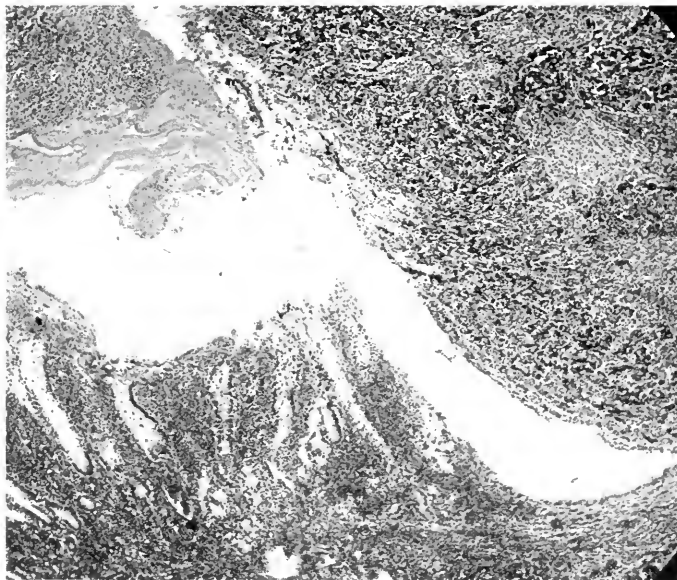


FIG. 7.—Edge of an ulcerating adenocarcinoma. The carcinoma (in upper right corner) is limited to a narrow peripheral ring protected by the overhanging edge of inflamed mucosa. The base of the ulcer is free from carcinoma. There are no atypical changes in the glands. The lesion is an early adenocarcinoma extensively excavated by the digestive action of the gastric juice.



FIG. 8.—Atypical proliferation and misplacement of glands on edge of an ulcer grafted upon diffuse carcinoma. The structure of the carcinoma is greatly altered by inflammation and cicatrization. The visible glands do not constitute the carcinoma.

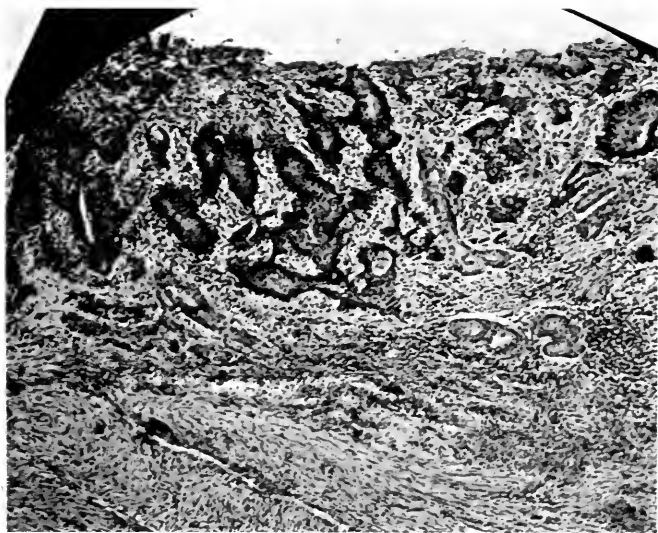


FIG. 9.—Atypical proliferation of glands on edge of a simple peptic ulcer. This lesion is not cancer.



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one visualizes the conditions which must exist for the development of cancer by atypical proliferation on the edges of an ulcer, it is clear that the process must take considerable time, probably months, certainly in the best attested cases many years, and the base of the ulcer must become indurated, fibrosed and infiltrated by leucocytes which are antagonistic to tumor growth. Close to the surface of such a lesion it may safely be said to be impossible for cancer to advance. The natural paths of extension of such a secondary carcinoma will be those of least resistance which are outward, and such was evidently the course in Hauser's cases. Hence great importance would seem to attach to the condition of the base of the ulcer in the diagnosis between primary and secondary carcinoma.

(6) The occurrence of atypical epithelial proliferation in the glands on the edge of an ulcer is not sufficient evidence that the lesion is going on to cancer (Fig. 9). A safe application of the doctrine of precancerous lesions recognizes that the suspicious lesions may never pass beyond the stage observed. This rule is especially patent in the breast and prostate, where atypical changes are very frequently seen in chronic mastitis and prostatitis, but the disease terminates in cancer at most in only 15 to 25 per cent. of the cases. The same rule doubtless applies to the stomach, in which I find atypical proliferation on the edges of peptic ulcers is rather uncommon.

From the above considerations the writer is forced to conclude that the cancerous transformation of peptic ulcer is rather infrequent and probably does not exceed the incidence of 5 per cent. originally established. This proportion would be much smaller if only those cases were included in which the evidence is demonstrative, viz.: a long history of gastric ulcer, the limitation of the tumor to isolated foci or one portion only of the ulcer, and freedom of the base from infiltration.

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## CAUTERY EXCISION OF GASTRIC ULCER

FURTHER OBSERVATIONS ON THE VALUE OF THE METHOD\*

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IN a previous communication<sup>1</sup> I described a method of using the actual cautery in the surgical treatment of gastric ulcer. At that time, the advantages of cautery excision appeared to be sufficient to commend it, and we believed that it would prove an important addition to the operations commonly employed in chronic gastric ulcer. Since that time, further experience has more than supported our early opinion of the method, its application has been greatly extended, and its value has been recognized by others, notably Scudder, Peck, and Coffey.

In the present communication I desire to make some observations based on 214 cases of gastric ulcer, in which the cautery has been employed in our clinic, to show the advantages of cautery excision and briefly to compare its results with those of other standard methods, particularly knife excision.

The first group of cases in which the cautery was applied comprised the lesser curvature ulcers in such high situations or so extensively indurated as to make knife excision an operation of difficult technic or poor surgical judgment (Fig. 1). Under the circumstances, although gastro-enterostomy alone could be counted on to relieve the symptoms in a certain percentage of persons with such ulcers, the advantage of being able, without additional risk, to destroy the crater of the ulcer, and to sterilize the infected area by means of the cautery, was perfectly obvious. The results in this group of cases were very satisfactory and the employment of the cautery was carefully extended so that at the present time in a large percentage of gastric ulcers the method appears to be the one of choice.

There are certain limitations in the method which should first be noted. Chiefly that it is not applicable to those ulcers which have definitely undergone malignant change unless the lesion is irremovable because of its size, situation or fixation, and that the procedure should be attempted only if the stomach can be sufficiently mobilized to enable safe exposure.

The value of the cautery in gastric ulcer seems to depend largely on two factors, namely, heat and perforation. The efficiency of heat as a sterilizing agent in infected fields is well known and widely employed. Heat has no superior in quickly and effectively destroying infectious foci, such as cervical, buccal or epithelial carcinomas, indolent ulcers, carbuncles, etc., and since Rosenow has demonstrated the elective localization of streptococci in gastric ulcer, the application of heat in such an infectious process is clearly indicated.

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\* Presented before the American Surgical Association, June, 1918.

Complete perforation by the cautery point through the centre of the crater of the ulcer (Fig. 2) has been made an essential in the technic because of the clinical fact (drawn attention to early by Mayo, Clairmont and others and now generally recognized) that spontaneous and complete perforation of a gastric ulcer is, presupposing recovery from this accident, quite likely to be followed not only by the cure of the ulcer, but by the cure of the patient. The frequency with which nature attempts perforation is shown by the fact that in a very high percentage of ulcers a protected perforation has occurred by the time they come to operation (Figs. 3 and 7). The cautery technic will almost always (particularly if a thin shaving of the calloused peritoneal coat is made following the careful reflection of the

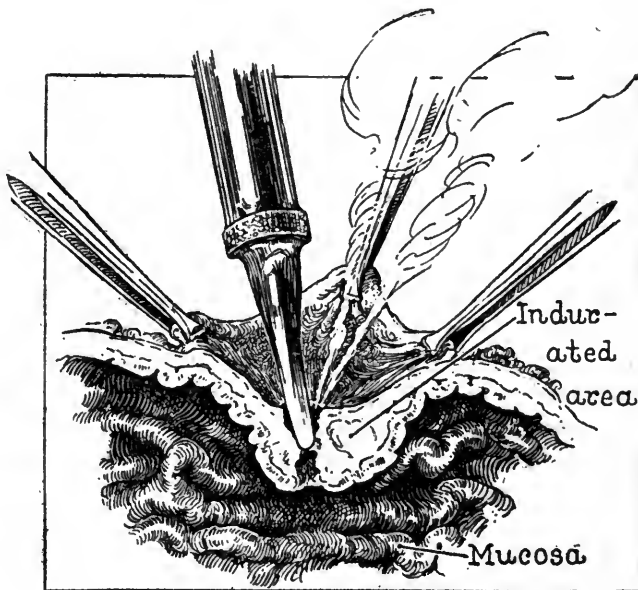


FIG. 2.—Complete perforation, by cautery, through the centre of the ulcer crater.

indurated gastrohepatic omentum from the wall of the stomach as shown in Fig. 4) reveal a minute but very definite point in the thickened gastric wall which marks the site from which the leakage has occurred, indicating the centre of the crater of the ulcer and serving as an excellent guide for the introduction of the cautery point (Fig. 5). Cautery puncture, combining as it does the beneficial action of heat with an artificial perforation, possesses a double efficiency and it is undoubtedly to these two factors that the success of the method is largely due.†

The most important advantage of cautery excision concerns its application in ulcers of the lesser curvature. In this situation the majority of gastric

† Since the original communication<sup>1</sup> Haines, of Cincinnati, has drawn my attention to the fact that perforation of a gastric ulcer by some blunt instrument had been proposed previous to that time.



FIG. 1.—Characteristic position of stomach with an ulcer of the lesser curvature. Moderately extensive induration and thickening of the gastrohepatic omentum.

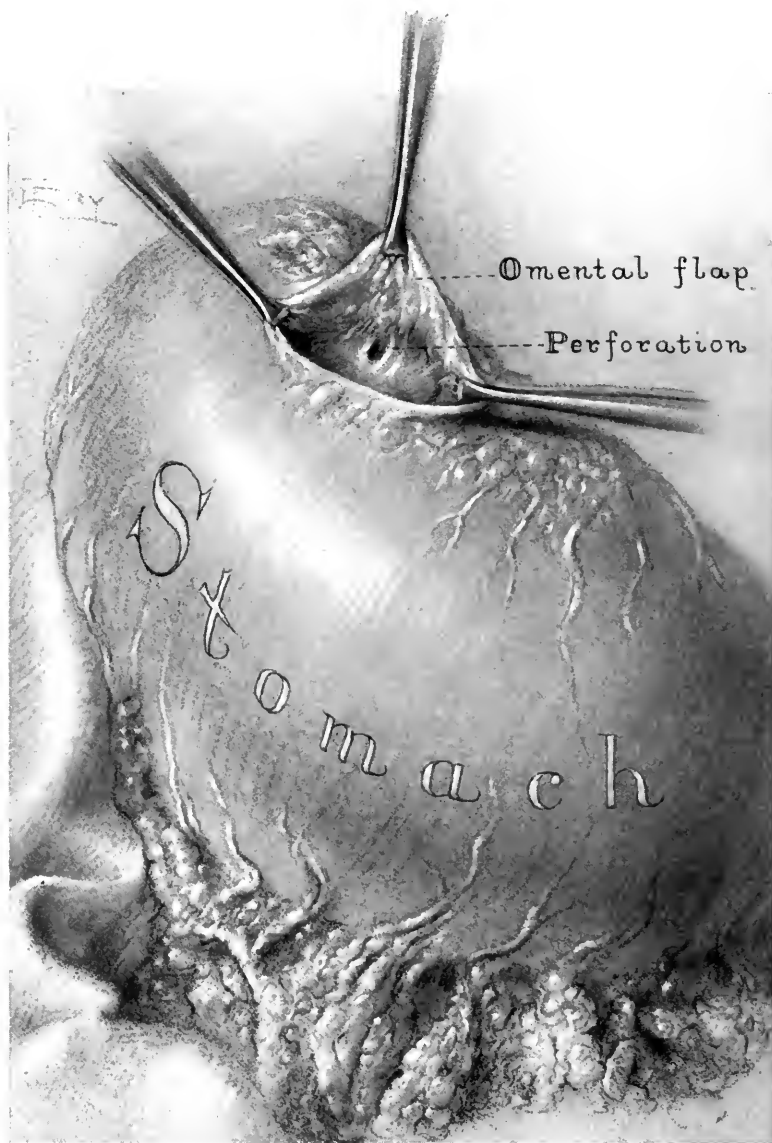


FIG. 3.—Gastrohepatic omentum dissected off ulcer area and peritoneal surface exposed.

## CAUTERY EXCISION OF GASTRIC ULCER

ulcers occur, but the high incidence has never been satisfactorily explained although certain suggestive facts are in evidence. For example, the blood supply along the lesser curvature is much greater and of different arrangement than that on the greater curvature, a situation in which ulcer occurs with the greatest rarity; while the lesser curvature of the stomach, as Barber has recently shown, is extremely rich in vagi and sympathetic terminals, although the distribution of motor and sensory function in these terminals is not known. The significance of these anatomical characteristics is not understood, but enough evidence can be obtained by experimental methods alone to show that the lesser curvature of the stomach may well be given more regard by surgeons than has been afforded it in the past.

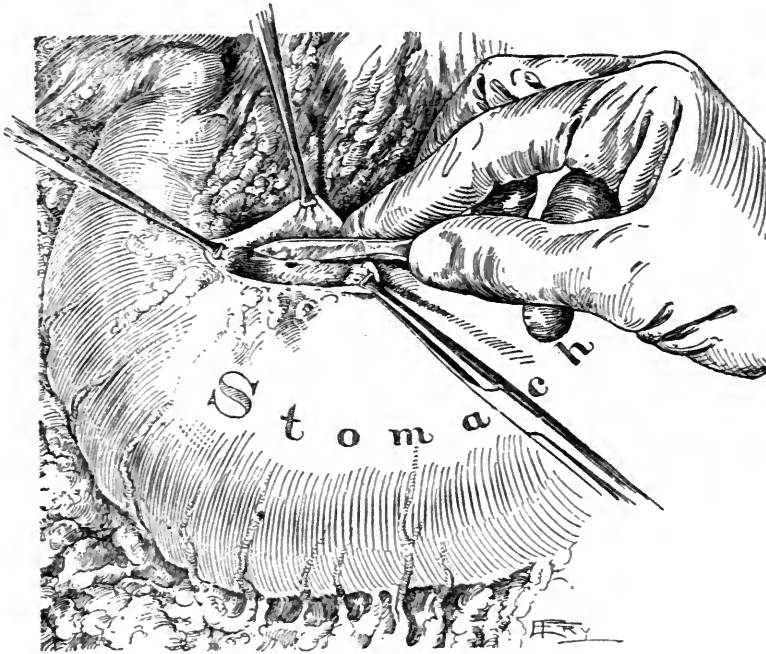


FIG. 4.—Shaving of thickened musculo-peritoneal coats.

Clinical experience, too, bears out the observations of Barber and Stewart that excision of a segment of lesser curvature does definitely impair gastric motility, for it is now well known that excision alone of a lesser curvature gastric ulcer frequently fails to completely relieve symptoms, and in order to obtain the best possible results such an excision must always be combined with gastro-enterostomy. Cautery excision, on the other hand, reduces to a minimum interference with the future motility of the stomach. Carman, in röntgenologic studies of stomachs following different types of operation, has recently demonstrated that cautery excision and gastro-enterostomy gives much better motility and function and results in much less deformity than does knife excision and gastro-enterostomy. This fact can hardly be over-emphasized. Notwithstanding, therefore, the good results which follow

knife excision and gastro-enterostomy, if cautery puncture through the crater of the ulcer, with gastro-enterostomy, will give at least equal results, it is, quite aside from advantages which will be pointed out later, a preferable method on the score alone of being less mutilating in its accomplishment.

One objection which may be raised against cautery excision is in regard to its effectiveness in those cases of ulcer undergoing malignant change and which are otherwise excisable, but I believe it may be shown that not only is any deficiency in the cautery method more apparent than real but that it possesses certain advantages under such circumstances. Without going into a discussion as to the frequency with which gastric ulcer becomes gastric cancer, I may offer one fact which seems to be of considerable importance from a surgical point of view. In a review, by means of a careful follow-up system, of the 1,004 cases classified as gastric ulcer, in which operations were done in the clinic, I found that in those patients dying months or years later from what was known to be gastric cancer (or, as was more often true, thought to be gastric cancer) almost invariably malignancy had been strongly suspected, the lesion was not safely removable, and a gastro-enterostomy only had been done. Investigation further showed that death eventually from gastric cancer seldom occurred in those cases in which the operative report stated gastric ulcer unqualifiedly. In other words, although the surgically untreated gastric ulcer possesses a strong liability to cancer degeneration, the gastro-enterostomized ulcer shows very little such liability. This fact discounts largely any criticism of the cautery method on the score of ignoring the malignancy factor. Such criticism is further met by the practice we follow of shaving off a portion of the ulcer base or rimming out the crater for microscopic examination before using the cautery, with immediate resection if the ulcer is malignant and operable. The fact, too, that the cautery can be used in a large group of cases in which excision is impracticable more than offsets any disadvantages of the method when used in excisable cases. The investigations of Thalhimer and Wilensky are important in this connection. They were able to show that gastric cancer, both primary and secondary to ulcer, is sharply demarcated from healthy tissue, and that local resection 1 or 2 cm. from the edge of the macroscopic evidence of the tumor is sufficient in the majority of instances to remove all the disease. This being true means that heat used in an ulcer undergoing malignant change can, by careful application, be effectual in destroying early malignancy if no metastases are present. The destructive action of heat on the cancer cell is so positive it is not unreasonable to hope that in some of these large irremovable ulcers which have already taken on early malignant change in the ulcer base, the thorough cauterizing of the base may destroy these cancer cells and prevent an otherwise certain death from cancer later.

The actual effect of the cautery may be studied from four standpoints, (1) experimental evidence, (2) clinical experience, (3) operative mortality and (4) late results.

The original experiments conducted under the direction of Mann to

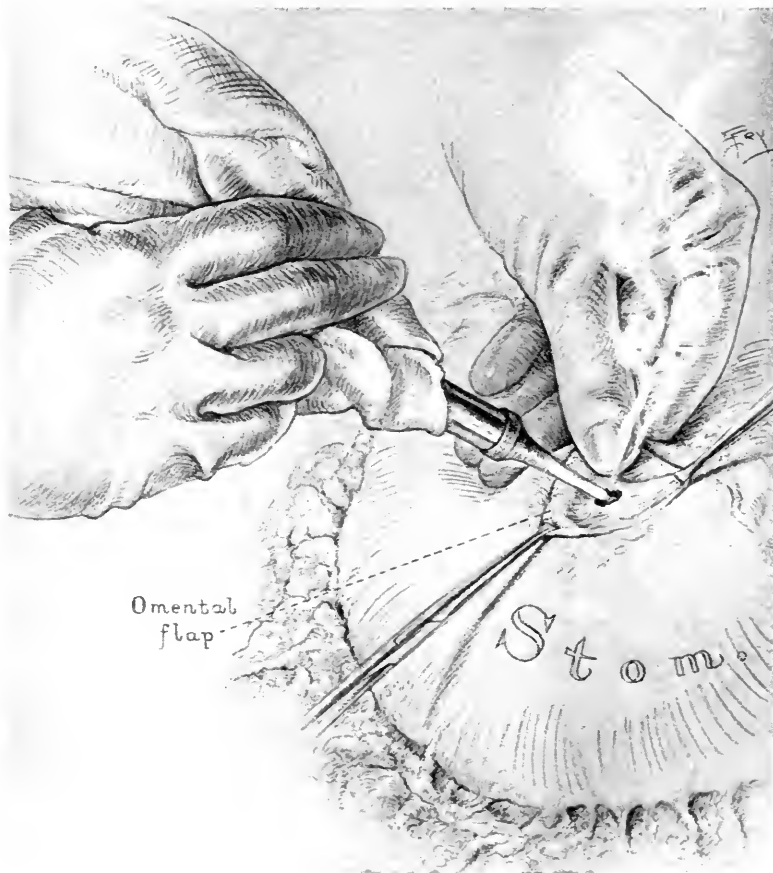


FIG. 5.—Peritoneal surface of ulcer prepared for application of cautery.

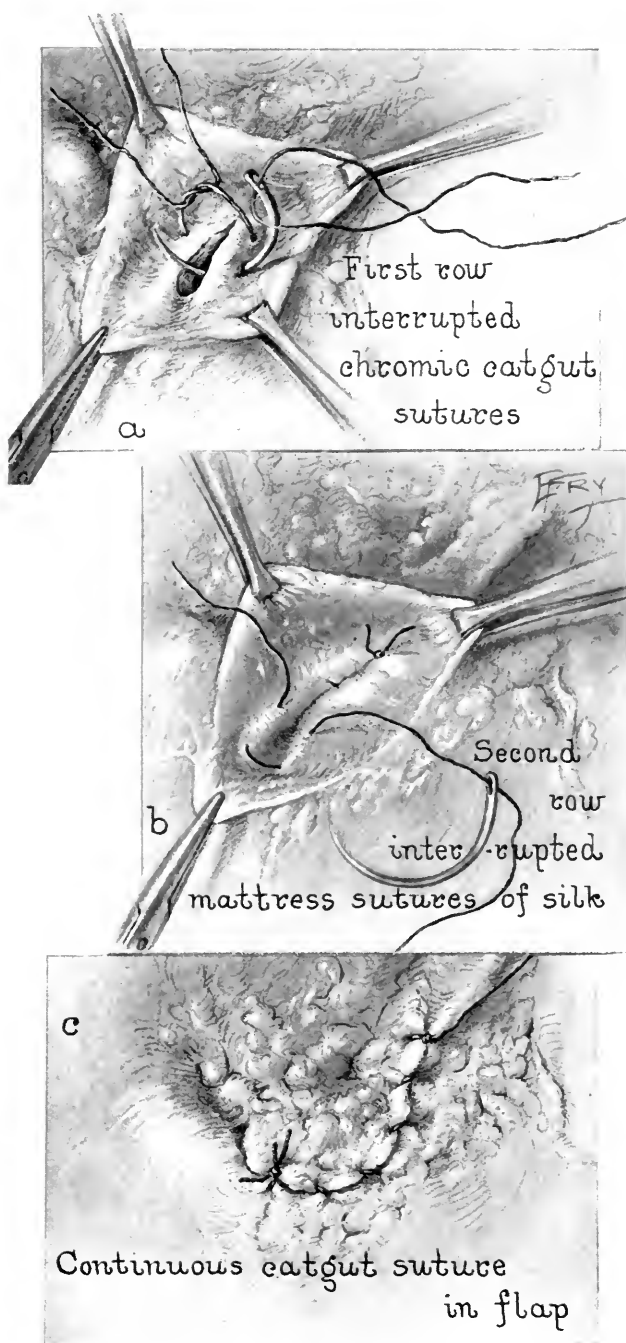


FIG. 6.—Method of closing cauterized opening. a, first row, chromic catgut sutures; b, second row, silk mattress sutures; c, third row, continuous catgut sutures.



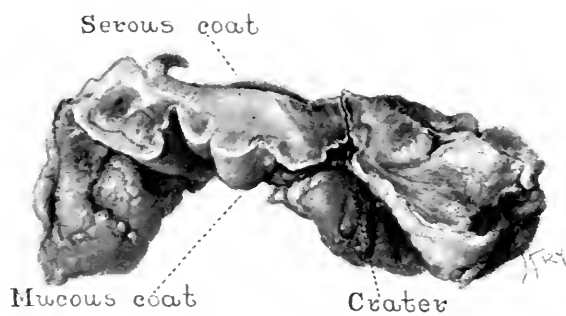


FIG. 7.—Cross-section of ulcer, showing tract of perforation.

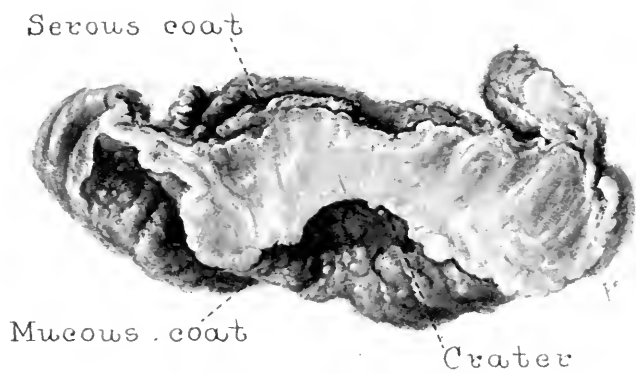


FIG. 8.—Half section of ulcer showing extensive induration.



## CAUTERY EXCISION OF GASTRIC ULCER

determine the healing power of the stomach after an opening had been made by the cautery, and closed by suture, demonstrated conclusively that rapid and firm healing uniformly took place, even when the closure of the cauterized opening was more or less imperfect. The experiments carried out by Scudder and Harvey confirmed this and they showed further that in serial sections of the line of closure following cautery excision and of that following knife excision no marked difference in rapidity of repair was demonstrated. Experimental evidence, then, has demonstrated the readiness with which healing takes place in these cauterized areas.

We have had only one opportunity of observing in man the late condition of the stomach after the operation of cautery excision. In 1915 I operated on a patient (Case 120281) for a large gastric ulcer of the lesser curvature. The induration was so extensive and extended so high on the lesser curvature that not only was excision quite contraindicated but the possibility of a second ulcer was considered. Only one crater could, however, be determined. This, after its exact location on the peritoneal side, was exposed by mobilization, was punctured with the Paquelin and thoroughly cauterized, the opening closed, and a gastro-enterostomy done (Fig. 6). The patient made a good recovery and returned home. Later he contracted lobar pneumonia followed by empyema, and he returned to the clinic acutely ill, where, notwithstanding prompt and efficient drainage, he died. At necropsy the stomach was the organ of particular interest. In spite of the great induration along the lesser curvature at the time of the operation, there was no evidence that any pathologic condition had existed or that any operative work had been directed toward the lesser curvature. The gastro-enterostomy was normal. These findings were extremely gratifying inasmuch as the result was obtained in a case in which knife excision could not be done, and in which heretofore a gastro-enterostomy alone would have been made.

The low operative risk of cautery excision and gastro-enterostomy is shown by the fact that in the 186 cases in which this was the major operation there were two deaths, giving a mortality in the series of only 1 per cent. The necropsy findings in each of these two cases demonstrated that the field of operation was in perfect condition; the cause of death in one being pulmonary embolus on the eighth day and in the other pneumonia on the twentieth day. In comparing these statistics with those of knife excision and gastro-enterostomy we find that in the 89 cases in which operation was done by this method 3 deaths occurred, a mortality of 3.3 per cent.

The convalescence of the patients in whom cautery excision and gastro-enterostomy are done is uniformly smooth, and the clinical postoperative course bears out Carman's observation that better gastric motility is attained than in those operations (particularly excision of a V-shaped segment in the lesser curvature) which entail greater damage to the musculature of the stomach. The reports of the late results, as they come in, are most favorable. Of the 61 cases in which the cautery was used in 1914-1915 we

have positive information in 55. In this number there have been 4 deaths from all causes since operation, 2 already mentioned following operation, the other 2 of unknown causes at their homes in the three or four years after leaving the clinic. Of the remaining 51 cases operated on in the two years 80 per cent. of the patients report a satisfactory result (cured and greatly improved), 18 per cent. were improved in the sense of amelioration of symptoms present previous to operation, while in no instance did a patient report that he had not obtained relief from the operation.‡ The cases of knife excision and gastro-enterostomy in this period show corresponding figures of 70 per cent. and 15 per cent., while 15 per cent. of the patients state they are no better. These figures of mortality and late results have more force when it is remembered that the knife excision cases are essentially selected, inasmuch as this operation is done only when conditions are favorable, while the cautery is often employed in the very case in which excision is unwarranted because of the size, fixity and situation of the ulcer.

As to the relief of special symptoms, I would draw attention to the very important fact that in not a single instance has there been a recurrence of hemorrhage from the ulcer following operation by the cautery excision method. It is well known by surgeons of experience that operations for gastric or duodenal ulcers which have been associated with bleeding, do not always obviate later gastric hemorrhages. That bleeding has not recurred thus far in any of our cases following the use of the cautery has been a source of considerable satisfaction. One of the primary purposes also of the cautery was to lessen the likelihood of immediate postoperative hemorrhage and in this the method has fulfilled expectations.

From a technical standpoint, excision by cautery accomplishes much in a simple way which is not true of excision by knife. It is a common observation that the induration around an ulcer is out of all proportion to the size of the crater (Fig. 8), and that excision sacrifices, along with the actual infected area, the protective induration with which nature attempts to wall off the infectious foci which exist in the crater. Our experience with the cautery has shown that this wide excision is just as unnecessary as it is in the treatment of infectious foci elsewhere and that the indurated area can be restored to a healthy condition by destruction of the crater and thorough heat sterilization of the surrounding tissues as the cautery is held in the punctured crater. The heat is an important factor and would destroy adventitious cells for from 1 to 2 cm. in every direction. The utility of the cautery is particularly well demonstrated, therefore, in greatly indurated ulcers (the actual size of the crater is rarely greater than a twenty-five-cent piece) which can be safely mobilized. Knife excision under such circumstances, necessitating as it does complete removal of the indurated area, is an

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‡ One patient (2 per cent.) after five months of relief developed similar symptoms and returned to the clinic. Re-examination disclosed indications of a gastrojejunal ulcer and operation confirmed such a diagnosis and corrected the difficulty.

## CAUTERY EXCISION OF GASTRIC ULCER

unsatisfactory procedure if some substitute is available which will accomplish as much without unnecessary sacrifice of gastric wall.

The cautery, therefore, has been found of very great usefulness in gastric ulcer. Although I have considered in this paper only the 186 cases of gastric ulcer in which cautery excision was combined with gastro-enterostomy, we have also used it without any other operative procedure, as well as with various types of gastroplastics and pyloroplastics. In a few cases we have employed it to destroy small duodenal ulcers, particularly those associated with hemorrhage, and it would appear that in such cases the method has particular usefulness of application.

The apparent advantages of the method may be summarized as follows:

1. The cautery efficiently destroys the focus of infection in gastric ulcer without the sacrifice of nature's protective induration surrounding the ulcer crater.

2. It may be applied in a large percentage of gastric ulcers.

3. It entails a minimum of operative risk.

4. Clinical and röntgenologic evidence show better motility and function than follow knife excision and gastro-enterostomy.

5. It has a particular efficiency in obviating early and late postoperative hemorrhage.

6. The late results are better than those obtained with any other method.

7. It can be used in cases in which no other means of direct attack on the ulcer is justifiable.

8. It is probable that in gastric ulcer cautery, like knife excision, should always be combined with gastro-enterostomy.

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## RELIEF OF UMBILICAL HERNIA BY THE CONDEMIN- RANSOHOFF TECHNIC \*

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ACQUIRED hernia at the umbilicus, as found in the adult, is a most difficult form of hernia to deal with, as it so frequently occurs in fleshy subjects who, before seeking operation, have allowed the hernia to grow to a large size and frequently to become strangulated. When strangulated, these cases early develop fecal vomiting, owing to the sac containing portions of the proximal small intestine. Patients with a fatty heart, fecal vomiting, a large mass of adherent omentum and possibly a portion of gangrenous intestine, present a condition which requires extensive operative measures and prolonged anæsthesia.

In the text-books and most of the articles treating with the radical cure of umbilical hernia, the entire detail is directed to the closure of the wound and not to the measures which may be taken to shorten the operation, and with it the period of anæsthesia. It is quite true when operating we should aim to obtain a radical cure, but it is equally true that a satisfactory and complete closure is of no avail if the patient is later to die as the result of the time taken to attain this.

In order that we may have the additional time necessary for the closure, our initial procedures should be so planned as to conserve as much time as necessary. The usual procedure has been to incise over the mass, open the sac, reduce the contents or deal with them as might otherwise be necessary, and then to excise the sac and close the wound.

In 1898 we began to operate by attacking the contents of the sac from within. The method of approach is as follows: An elliptical incision is carried about the tumor so as to remove as much skin as necessary, or to surround any ulcerated area. As soon as the sac is reached it is isolated down to the ring, completely exposing the fibrous structure, and extending a couple of inches above, below and laterally.

An incision is now made in the median line an inch below the ring, and the peritoneal cavity opened; the finger is introduced and with the scissors the incision is carried completely about the ring, first on one side and then on the other, until the median line above is reached. The only point at which there is danger of dividing the intestine or omentum is in the upper segment. When this division is completed the entire hernial mass, including the sac, fibrous ring and contents, is lifted free from the abdominal cavity.

The next step is to remove the contents from the sac. To do this the fibrous ring is divided sufficiently to allow an inspection of the interior of the sac; the intestine and any free omentum is withdrawn and placed in the

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\* Read before the New York Surgical Society, April 10, 1918.

## RELIEF OF UMBILICAL HERNIA

abdomen. The omentum is usually in large amount and adherent everywhere to the wall of the sac. It is not necessary to dissect this free, but, instead, it is to be ligated at the ring and the adherent portion removed with the sac.

Gangrenous intestine, if present, should not be removed from the sac, but excised, *in situ*, and anastomosis made. This saves much time and avoids handling the gangrenous intestine.

This technic we have used in a large number of cases, many of which have been strangulated. By this method the operative procedure has been simplified and much shortened and our mortality has been very materially reduced.

The procedure here outlined we presented before the Medical Society of the County of Kings<sup>1</sup> as an original procedure, but later found that it had been, with slight differences, previously described by both Condemin and Ransohoff.<sup>2</sup> To the latter is due the credit of first having given a complete description and drawn attention to its many advantages.

The only text-book which describes this operation in detail mentions it as a part of the Mayo operation for radical cure of umbilical hernia, although Mayo in his original paper<sup>3</sup> gives full credit to Ransohoff; Mayo's contribution dealing particularly with the method of closure.

The technic above described has the advantage of preparing the wound for closure by any of the recognized methods. If there has not been a wide separation of the recti, the edges of the sheaths are usually opened when dissecting out the fibrous ring, and we have the parts well exposed for immediate suture in layers.

For the Mayo method of closure it is equally well adapted, as the aponeurosis can easily be overlapped from above downward and the transverse suture introduced.

This technic is presented as it has the following advantages over any other method of approaching the sac in umbilical hernia:

First, it is the simplest method of dealing with the contents of the sac.

Second, if gangrenous bowel is present it may be removed without handling.

Third, large masses of adherent omentum can be removed with the sac and thus save the time necessary to free the many adhesions.

Fourth, if there are any ulcerated skin areas they are removed with the primary incision.

Fifth, it shortens the first stage of the operative procedure and greatly reduces the mortality.

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<sup>1</sup> Brooklyn Medical Journal, vol. xv, No. 12.

<sup>2</sup> Medical Record, vol. li, No. 5.

<sup>3</sup> ANNALS OF SURGERY, vol. xxxiv, p. 276.

# CONGENITAL IDIOPATHIC DILATATION OF THE COLON OR HIRSCHSPRUNG'S DISEASE

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HIRSCHSPRUNG'S name<sup>1</sup> has become attached to this disease because his classical description of it at the meeting of the Berlin Congress for Children's Diseases in 1886 first brought its existence as a clinical entity to the general attention of the profession. In 1908 Finney,<sup>2</sup> collaborating with A. W. Fisher, presented a bibliography of 206 articles, complete to the time of his writing, and showed that more than twenty cases had been collected before Hirschsprung's. In his masterly contribution three additional cases were reported and the subject was exhaustively considered from every viewpoint. The first report on record seems to have come from the pen of Parry<sup>3</sup> in 1825. The first report in this country seems to have been made in 1867 by Lewitt,<sup>4</sup> of Chicago. In the nine years which have elapsed since Finney's monograph, about 175 articles on the subject have appeared, 147 references being appended to a case reported by Cadwallader<sup>5</sup> last year. Two of the most interesting and instructive of these contributions are those by Barrington-Ward<sup>6</sup> and by Porter and Weeks.<sup>7</sup> The disease is not so rare as most text-books would lead one to believe. All together more than 400 cases have been collected. Smith<sup>8</sup> states that he had seen 8 cases and had found 26 not included in previous collections in addition to 358 cases gathered by Schneiderhölml<sup>9</sup> in March, 1915, making a total of 392 reported to October 1, 1915.

The object of this paper is to add to the rapidly growing literature on the subject the report of one more case of true, congenital, idiopathic dilatation of the colon, to describe its pathology and to discuss it in the light of the etiological causes as listed by Finney. I am indebted for the opportunity to Dr. B. F. Zimmerman, who successfully operated and restored the patient to normal health and kindly presented the specimen to the museum of this department after exhibiting it before the Jefferson County Medical Society. The clinical data furnished by Doctor Zimmerman follow:

*Clinical Data.*—Miss O. R., aged twenty-one. Referred to me by Dr. C. L. Nichols, on January 17, 1915.

*History.*—Patient has suffered from habitual constipation since infancy. Large doses of strong purgatives have always been necessary. It has not been unusual for her to go from two to four weeks without an evacuation of the bowel. Enemata of little avail, the fluids usually being retained. She gives no history of any illness which could pos-



## CONGENITAL IDIOPATHIC DILATATION OF THE COLON

sibly be connected with her present trouble. Does not suffer from headache. Does not vomit. Appetite poor. Complains of a feeling of lassitude. Following an X-ray examination by Doctor Keith, a report of which is herewith included, Doctor Nichols, with the idea that the condition might be due to some obstruction by the valves, applied Pennington's rectal valve clips. These produced a destruction of a portion of the valves but afforded no relief.

*Family History.*—Had a baby sister who died in infancy from a congenital obstruction and has a sister four years old who has never been able to talk. Her mother has a large goitre, of the adenomatous type, in my opinion.

*Report of Radiographic Examination (Doctor Keith).*—Examination was made February 2, 1915. After cleansing the big bowel by enema, an enema of barium solution was given until the patient felt some discomfort. The amount of solution used was seven pints. A plate was made at this time which gave a shadow of a rather small rectum and a very large, dilated big gut from the junction of the sigmoid and descending colon to the cæcum. The transverse shadow of the descending colon is probably three inches in diameter, the cæcum being probably four inches in diameter. The splenic angle extends as high as the seventh rib, plates being made in the supine position. Diagnosis: Congenital megacolon or Hirschsprung's disease, probably due to congenital, anatomical narrowing of the rectum.

*Operation and Subsequent History.*—On May 12, 1916, a short circuiting of the bowel was done, the ileum being detached from the cæcum and by lateral anastomosis united with the sigmoid by means of a Murphy button. The colon was found greatly dilated from the cæcum to the lower part of the sigmoid, where it gradually reduced to normal diameter. Nowhere, however, even to the anal opening, was found any obstruction. The patient did well for eleven days, when she began to show symptoms of partial obstruction. These symptoms increasing, she was again operated May 24. The button had disappeared and the anastomosis was perfect. A kink in the ileum about two inches above the site of anastomosis, a result of adhesions, was producing the obstruction. A second anastomosis was done three inches above the first by the suture method. Recovery was uneventful. Following recovery from the second operation the patient did fairly well. She required much smaller amounts of purgative medicine. The colon, however, continued to fill up at times with gas and annoyed her greatly. So pronounced was this annoyance that she insisted upon the removal of the colon. April 23, 1917, colectomy was done. The ascending portion of the colon was apparently not much affected. The transverse and descending colon were enormously enlarged, the walls thick and leathery and the surface a grayish white. There was a long mesentery at the splenic flexure.

The patient made a complete recovery and since leaving the hospital, May 15, 1917, has taken but two doses of purgative. At the time of colectomy, the ileum was found to be considerably dilated. At present (May 1, 1918), the patient does not suffer from gas or consti-

pation. Her appetite is good. She has increased in weight, feels normal and is in a nurse's training course. She passed the Murphy button about May 5, 1917, nearly one year after its introduction.

*Pathological Examination.*—Gross: Specimen consists of large intestine to lower portion of descending colon (Fig. 1). Distal end is closed with a drawstring, which puckers it like a meal bag, to hold air with which specimen has been dilated. In this condition it has the following measurements: Length, 110 cm.; circumference about cæcum, 25 cm.; about ascending colon, 21 cm.; just proximal to hepatic flexure, 12.5 cm.; about middle of transverse colon, 20 cm.; about descending colon in largest part, 31 cm. Proximal end is formed by dilated cæcum from which, at site of ileocæcal valve, projects a puckered knob over which some fat has grown. On dissecting away latter, stump of cæcum is found about 20 mm. long. At meeting point of lineæ tinea is a smaller knob which marks site of removed appendix. Both knobs are healed. In distal half of specimen wall is stiff, thick and leathery, pale grayish-brown with dilated vessels. Serosa is glistening, but through it circular muscle fibres appear distinctly, making line-like, annular ridges, while less distinctly the longitudinal fibres appear. There is little fat on this portion of specimen. Wall of proximal half is more normal, thinner and more flexible and yellower on account of more abundant fat. Mesocolon is absent from entire specimen. When opened, specimen is found practically empty. A small amount of faeces in a few places appears as thin flakes of pale brown plastered against mucosa. Mucous membrane is smooth, pale, grayish-brown, with a tinge of yellow and appears flattened and pressed out smooth. There are a few scattered, dark reddish-brown, oval or circular to irregular areas which look as if they might be pigmented with old blood. No ulcers found anywhere. When compared side by side a piece of hypertrophied distal portion appears three times as thick, macroscopically, as a piece from wall near the cæcum.

*Microscopic:* In two sections cut from thin wall of cæcum and from thickest portion of hypertrophied wall of descending colon the most striking difference is in muscularis which is from three to five times thicker in latter than in former. Mucosa in latter is also a little thicker, but no other lesion can be made out (see Figs. 2 and 3).

*Discussion.*—Hirschsprung's own division of dilated colons into those occurring in infancy (true megacolon) and those occurring in adult life (pseudomegacolon) is generally accepted. For the former German and Dutch authors use the term "Hirschsprung's disease," while French, English and American authors seem to favor the title "congenital idiopathic dilatation of the colon." The latter is preferred by Finney because it more nearly expresses our conception of the pathogenesis of the disease. There is abundant evidence that the disease has its origin in utero in a majority of cases. Its real cause is unknown. The acquired form results from some obstruction which develops after birth. For example, one<sup>10</sup> followed an operation for imperforate anus; another<sup>11</sup> followed fibrosis caused by earlier thrombophlebitis. The constrictions shown in Fig. 1 are like those mentioned by Leggett,<sup>12</sup> who found similar ones at the hepatic and splenic flexures and in the transverse colon. The congenital influence in this case is emphasized by the history of an infant sister who died without ever



FIG. 1.—Dilated colon showing splenic and hepatic flexures in natural positions. Puckered distal end marks site of section of descending colon above surgical anastomosis.

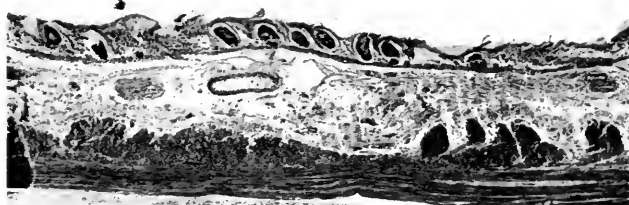


FIG. 2.—Photomicrograph of wall of cæcum (x 35).

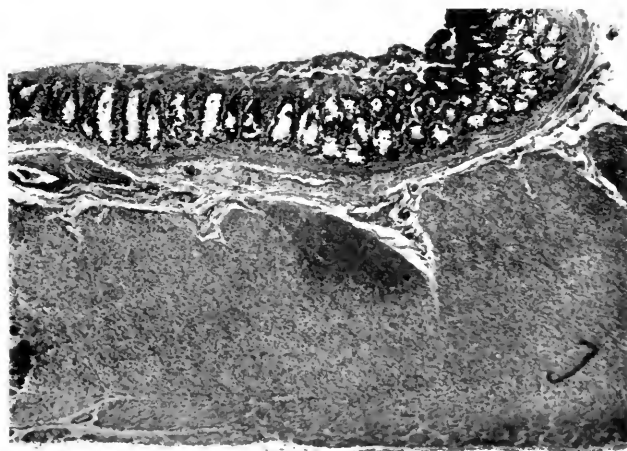
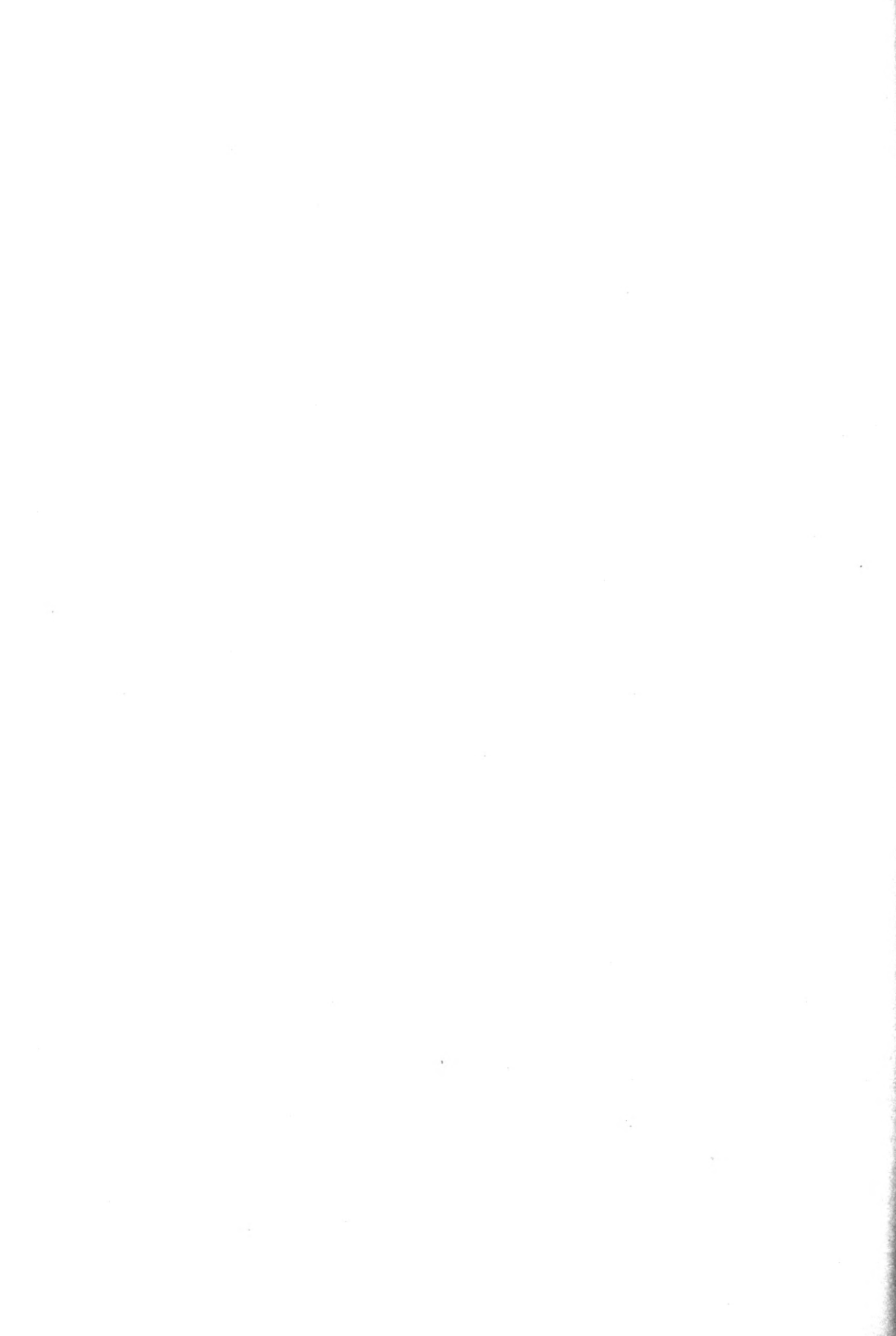


FIG. 3.—Photomicrograph of thickest portion of hypertrophied wall of descending colon (x 35).



## CONGENITAL IDIOPATHIC DILATATION OF THE COLON

having had a normal bowel movement. Welt-Kakels<sup>13</sup> reports a like feature in a case of an adolescent boy whose mother had borne another male baby who had died when eight years old. The latter never had a natural movement.

For a detailed discussion of the etiology of Hirschsprung's disease one should consult Finney's article. So far as the case herein reported is concerned it would seem to fit the view of Mya's modification of Hirschsprung's theory; namely, that the dilatation was a congenital anomaly and that the hypertrophy was a second process.

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## MECHANICAL DERANGEMENT OF THE KNEE-JOINT \*

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THE knee-joint is the largest joint in the body, and, when considered from a purely mechanical point of view, would appear to be too weak and unstable to carry out its function. This apparent weakness is owing to the structure of the bony parts; the strength is furnished by the ingenious short, strong ligaments augmented to some extent by the insertion of the muscles into the ends of the bone comprising the joint. If the knee were called upon merely to support weight, the problem nature is confronted with would be simple, but in order that man may walk, motion must be permitted. This means that the various ligaments entering into the structure of the joint must be so arranged that when one is relaxed by a certain motion another will tighten to give the necessary stability.

The knee is a specialized hinge-joint and would have a mobility of 180 degrees if flexion were not stopped by the impingement of the calf on the thigh. Normally, with the knee extended, there is no lateral mobility or rotation permitted. Occasionally a person is seen who has some lateral motion with the knee fully extended. This stability lessens as the knee is flexed and lateral motion and rotation begin at a flexion of 150 degrees and increase as flexion increases. Morris states that a rotation of 36 degrees thus becomes possible, which is extremely important because damage to the semilunar cartilages occurs when this "arc of weakness" is entered.

The capsule surrounds the joint, and specialized parts of it are called ligaments. At the front is the patellar ligament arising from the tibial tubercle and the lower end of the patella, the latter merely a sesamoid bone in the tendon of the quadriceps. The capsule extends above the top of the patella for 2 inches or more, forming the suprapatellar pouch. On the inner side is placed the internal lateral ligament, a broad fan-shaped structure with the base upward, really a thickened portion of the capsule and not readily distinguishable from it. That the internal semilunar cartilage is very intimately associated with the ligament by the strong fibres of its deep layer is a fact of practical importance (Fig. 1). On the outer side is placed the external lateral ligament, a structure more deserving of the name of ligament, and it is oftentimes in two distinct parts. This ligament is separated from the true capsule by fatty tissue and the popliteus tendon lies between it and the bone. It arises from the external tuberosity of the femur, runs down and is inserted into the head of the fibula, piercing the tendon of the biceps. The external semilunar cartilage has not the same intimate connection with the ligament that its companion on the inner side has (Fig. 1). Posteriorly, the

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capsule is reinforced by a strong band of ligamentous tissue known as Winslow's ligament. It is of no special significance to the topic under discussion, except that it has to be divided when exploring the posterior compartment of the joint. The semilunar cartilages are crescent-shaped structures, fibrocartilaginous in consistency. They are wedge-shaped in cross-section, the thicker part being at the periphery of the joint and attached more or less firmly to the capsule. The thin portion points to the inner part of the joint, is free and can be lifted from the articular surface of the tibia. The external cartilage is almost circular, the narrow ends being attached in front of and behind the fibular facet of the tibial spine. The internal cartilage does not form such a complete circle. Furthermore, the anterior extremity is more or less loosely inserted into the rough surface near the anterior border, a matter of significance in considering the great frequency with which trauma is inflicted on the internal semilunar cartilage. Nature has attempted to remedy this somewhat weak insertion by providing a transverse ligament to join the two semilunar cartilages. The posterior end of the internal meniscus is attached to the back of the tibial facet of the spine and is firmly fixed. The firm attachment of the thickened convex border to the capsule and internal lateral ligament is of importance for the reason that any pull on the capsule tends to move the internal cartilage. Some fibres of the quadriceps are inserted rather low down on the inner side of the capsule and this prolongation might pull in such a manner as to disturb the normal contour of the fibrocartilage, thus causing the anterior extremity to be caught between the bone ends on attempted extension. The crucial ligaments are situated well inside the joint. The anterior or external arises from in front of the tibial spine and passes outward, upward and backward to be inserted into the internal posterior surface of the external condyle. The posterior or internal ligament arises from in back of the tibial spine and passes upward, forward and inward to be inserted into the anterior end of the external surface of the internal condyle. The anterior prevents the slipping forward of the tibia on the femur and the posterior prevents the backward slipping.

Below the patella is a fat pad extending under the upper portion of the ligamentum patellæ. Passing up from this pad to the intercondyloid notch is the ligamentum mucosum. Below, it is continuous with the synovial fringes at each side of the lower margin of the patella which forms the ligamentum alaria. Davis has suggested that these ligaments perform the function of "wipers" for the knee-joint, spreading the synovial fluid over the condyles as motion takes place.

Mechanical derangement of the knee-joint is a term generally used to designate a clinical entity produced by intrinsic causes. The condition is due to some disarrangement of the internal structures of the joint, caused by injury of the joint surfaces, the semilunar cartilages, the fat tags, or, if the term is broadly used, rupture of the crucial ligaments may be included. Occasionally in civil practice, the cause of the derangement may be found to be a body of extrinsic origin, such as a bullet. The great war has already

furnished numerous instances of bullets loose in the joint. As a definite group, the causes of the derangement, as seen in cases in the Mayo Clinic, have been due, respectively, to the internal semilunar cartilage, loose osteo-cartilaginous bodies, the external semilunar cartilage, and foreign bodies. From January, 1910, to March, 1918, we have operated on 162 patients for derangement of the knee. The internal semilunar cartilage was removed in 96 instances; loose bodies, osteocartilaginous in structure, in 57; the external semilunar cartilage in 5, and foreign bodies (extrinsic) in 4. In three instances the joint was opened and, no pathologic condition being found, it was closed. In two of these cases a search was made for loose bodies.

The symptoms produced by a damaged loose or fractured internal semilunar cartilage are usually quite definite and the diagnosis is correspondingly easy. The history as to the exact method of the production of the injury is important. The syndrome is typical, although the accident may be so sudden, the actual duration so short and the patient so confused, that it is occasionally impossible to obtain a clear history. It is generally conceded that injury to the semilunar cartilages very rarely, if ever, occurs with the knee in full extension. Derangement of the cartilage is quite common among the coal miners in England, caused, no doubt, by the position assumed by them in the low mining shaft, necessitating working with the knees partially flexed. In such a cramped position a man can usually better maintain his equilibrium by having the feet in moderate eversion. It is in just this position that the derangement is produced, namely, partial flexion of the knee with eversion of the foot causing some rotation outward of the head of the tibia on the femur. As I have stated, there is, when the knee is slightly flexed, a certain laxity of the joint permitting some lateral mobility and rotation. With the knee flexed to about 150 degrees and the foot everted and rotated outward, the relaxed internal lateral ligament allows of some separation of the internal condyle from the internal tuberosity of the tibia. When the accident occurs and the force continues, with the foot in eversion, there is a tendency for the tibia to rotate outward on the femur, carrying with it the internal semilunar cartilage, and as attempt is made to extend the knee, the internal condyle of the femur rolls down on the anterior extremity of the cartilage, catches and holds it. Something must give way. The semilunar cartilage must slip from between the bones (the most fortunate thing that can happen), the applied force must stop in time (almost an impossibility) or the cartilage will be torn from its anterior attachment or fractured. The meniscus is fibrocartilaginous in structure, and very seldom tears completely in two. It may rip in a multitude of ways, perhaps the most common being a tearing free of the anterior third or fourth so that it lies loose, attached by a pedicle in the joint. Such an injury is followed by locking of the joint at intervals, causing various degrees of disability. If the rotation of the tibia on the femur is considerable at the time of the accident, the condyle of the femur may catch the cartilage farther back and rip it longitudinally through the middle three-fifths. The outer piece of the cartilage will then be forced outward and will lie to



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the outer side of the inner condyle near the crucial ligaments, being still intact at the anterior and posterior fifths (Fig. 2). The clinical history in such a case is usually that the disability following the accident is marked, the swelling and effusion persist for some time, but the dominant residual sign is lack of full extension. Flexion in such a case is usually normal and there is seldom the recurring of the locking that is present in the case in which there is a loose anterior extremity or a loose body. The patient presents himself with some effusion in the knee-joint and lack of extension and gives a history of a feeling of insecurity on walking that may necessitate crutches. The symptoms depend largely on the type of injury inflicted on the cartilage. If the history of locking is not definite or the physical signs, for example, lack of extension, are not definite, the surgeon should beware. Often the patient does not tell his story well and it is only by carefully going over and weighing the details that a conclusion can be reached. It is interesting to note that in the armies at war, this train of symptoms is seized on by the slacker as a means of being invalidated out of service and only by the most careful investigation of the symptoms can it be ruled out. There may be such a laxity to the capsule in certain cases, in which the knee is partially flexed and the foot rotated outward, that the anterior portion of the internal meniscus will be caught on extension, and will slip out before serious damage is done. Pain, effusion, and disability will ensue. At operation, an almost normal looking cartilage may be shown with but a trifle too much mobility, such motion being participated in by the capsule in this area. In such a case, removal of the anterior three-fifths of the meniscus affords relief.

It is generally conceded that the patient should not be operated on if there has been only one locking or derangement. This is particularly true if the semilunar cartilages are involved. It is probable that if all derangements of the knee, accompanied by locking, were treated by reduction at the time of the accident, and followed by a plaster-of-Paris cast for from four to six weeks, there would be comparatively few recurrences. Unfortunately, this is not done, and the usual story is that there are repeated lockings following the accident, making surgical intervention necessary.

In cases in which there has been locking for years, the loose end of the cartilage may be palpable, and occasionally it has deposits of calcium in it sufficient to cast a shadow in the röntgenogram. As an aid to diagnosis of semilunar cartilage derangement, the röntgenogram is useful only in excluding loose osteocartilaginous bodies, but it should be employed in every case of knee-joint derangement. The semilunar cartilages are most frequently the cause of the disability in early adult life, although they are by no means limited to this period.

The external semilunar cartilage is much less frequently involved than the internal and there are very good reasons for this. The rotation and lateral mobility are less on the outer side and the external meniscus is quite loosely attached to the capsule; thus it is permitted more motion and is able to glide out of harm's way. The shape, as has been mentioned, is different,

as the anterior and posterior extremities nearly meet at the tibial spine, and the circle is practically complete. The internal meniscus is more C-shaped, the anterior extremity being loosely attached. In this series of 101 operations on the semilunar cartilage, the external was removed five times. In two of these, the results have been unsatisfactory; it is probable that that cartilage was not at fault and we must acknowledge an error in diagnosis. Jones states that to eight internal semilunar cartilages at fault the external cartilage is at fault but once. Other authorities place the proportion anywhere from 10 to 1 or from 50 to 1. In this series, it is certainly no lower than 20 to 1. It, therefore, is clearly evident that an external semilunar should be removed only on a definite history of pain on the outer side of the joint, in conjunction with distinct locking. Jones has seen cases with derangement of the external semilunar cartilage in which the pain was all referred to the inner side. The removal of a damaged semilunar cartilage gives most excellent results. The technic employed must be rigidly aseptic; the operation is simplified by the use of the tourniquet. The type of incision used is the lateral, or so-called condylar, care being taken that the internal lateral ligament is not needlessly sacrificed. On the outer side, the external lateral ligament is placed more posteriorly and is readily avoided. While splitting the patella longitudinally gives better general inspection of the joint, it is not well adapted to the removal of the semilunar cartilages. The knee should be kept at absolute rest for one week after the operation, and this is best accomplished by a plaster-of-Paris case. Some surgeons advise putting the patient in bed with merely a bandage about the knee, and encourage motion immediately. There are two objections to this. First, the patient on awakening from the anæsthetic may move the leg too freely and cause hemorrhage. Second, it is much better to keep any wound at rest until the blood-clot has had time to partially organize. The superficial stitches may be removed at the expiration of a week, the deep sutures three days later, and the patient encouraged to get about on crutches, putting a little weight on the leg. Two weeks after operation he should be without support of any kind. A little effusion may follow, but if the knee is bandaged this will gradually subside. In three weeks the patient is usually fit for his work.

Loose bodies next to the internal semilunar cartilage in this group have been the most frequent cause of derangement. In a general classification of loose bodies, would be included the loose bodies of unorganized tissue, such as the corpora oryzoidea (rice bodies), found in tuberculosis, but which never cause mechanical derangement. Occasionally a mechanical derangement may be due to a fibrous, pedunculated loose fat tag. In no case in this series could this be definitely decided on as the sole cause. Fat tags were removed in three cases in conjunction with the internal meniscus. Therefore, I shall discuss only loose bodies of definite structure, osteocartilaginous bodies, or those of foreign substance, such as a bullet or a needle, although the latter may be almost disregarded in this series, since there were but four, one bullet, and three needles. The needles were not, strictly speaking, loose,

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one being in the soft tissues and the others in the cartilage of the internal condyle.

The osteocartilaginous bodies may be said to be produced in three ways, although trauma enters into the etiology in all. A loose body may be produced by direct trauma in a normal, healthy knee. A fall on the flexed knee against a hard object, such as a stone, may inflict such severe trauma to the internal condyle of the femur, the external condyle, or the patella, that a piece of the articular surface may be knocked off. In our experience, the internal condyle has been the most frequently involved in this manner. In one case suspicion seemed to point to the external condylar surface as the point of origin. In no case has the patella been the demonstrable origin. In our cases, syphilis *per se* has not been an etiologic factor. We have noted the presence of loose bodies in certain Charcot knee-joints, but have not considered that they should be classified under mechanical derangements, and in this paper they are not taken into consideration.

There has been definitely established as a clinical entity a group of persons who are prone to produce loose bodies, in every instance in this series the internal condyle of the femur being the area responsible. Koenig first described this condition, giving it the name of osteochondritis dissecans, and in this country Freiburg and Wooley and Ridlon first drew our attention to it. In a few instances, we have encountered it in both knees. The trauma or motion producing the body, or at least producing the first symptoms, is usually trivial and nothing particularly unusual, such as when the person turns sharply or arises from a sitting position on the ground. It is quite evident that the joint surfaces are not healthy in such cases. For some reason, desiccation of an area takes place, generally on the internal condyle a little to the inner side and just adjacent to the point at which the posterior crucial ligament is inserted (Fig. 3). Koenig's theory was that the end artery supplying this area became plugged and the part became under-nourished and sloughed off. In one instance a young man had recurrent locking. The röntgenogram showed the typical picture of osteochondritis dissecans, the body evidently resting in the depression where it originated (Fig. 3). On opening the joint, the area was readily distinguished, a line of demarcation could be traced surrounding the body, the latter being about three-fourths inch in circumference. It was necessary to cut the body loose in order to remove it. Whether or not the body had ever been free was not definitely clear. It may have been previously hanging on a pedicle, have become lodged in the depression and fibres had formed about it to hold it there. My impression was that these thin adhesions were not strong enough to have held the body there indefinitely and that it would later, on the infliction of some slight trauma, have become a loose body. The number of loose bodies produced in this way rarely exceeds two or three and careful inspection of the röntgenograms will disclose the source as a flattened area in the internal condyle.

The patient may present a knee actually distended with loose, movable

cartilaginous bodies which feel like a sack of marbles. The röntgenogram may show a synovial cavity greatly distended with a varying number of these bodies (Fig. 4). Bland Sutton reported one case in a young woman who had 1047 bodies removed without a recurrence of symptoms. In one of our cases more than 200 were removed. Such a condition had best be described as osteochondromatosis. The röntgenograms show the joint lines to be clear, thus forcing us to look further for the cause. On opening the joint, the picture is unusual. There is an associated synovitis; the lining is inflamed, somewhat thickened, and pedunculated into teats. These pedunculated masses vary in size, some are fibrous on the tip while others, still more advanced, are cartilaginous, becoming bulbous. As these bulbous portions become gradually larger and heavier, they drop off, wander about the joint and, nourished by the joint fluid, increase in size. What the etiologic factor back of this is, it is impossible definitely to determine. That it is of infectious origin does not seem plausible. There are factors which suggest it to be of the order of new growth. The synovial membrane is developed from the same layer of mesial blastema as is the cartilage of the joint surfaces, and it has been suggested by Whitelocke that the synovia tends to take on cartilaginous structure. In one of our cases, this condition developed coincidentally with a chondromatous formation in the lower end of the femur and later became malignant, the patient becoming cachectic, and dying with metastases in the lungs (Fig. 5). Such an association of growth on the synovia and in the cartilage is evidently rare, but very suggestive that the condition is a benign neoplastic one. Our patients with only the synovia involved have remained well, and in all the reported cases the patients have apparently had no recurrences. Just why the process should be brought to a standstill by the removal of the large formed bodies is difficult to understand; however, it is a clinical observation substantiated by but comparatively few cases.

The symptoms produced by the loose body or bodies are catching or locking, at irregular intervals associated with pain and perhaps effusion, followed by a period of relief depending on whether or not the body finds a resting place that does not permit of its being caught between the articular surfaces. If it lies above the patella in the suprapatellar pouch, in the posterior compartment, or even in the intercondylar space, locking will be absent. The irregularity and uncertainty of the locking, producing pain and sudden disability sometimes so extreme that the patient may fall to the ground, causes him to seek relief. Effusion may be present, and hypertrophic arthritis, although whether the latter produces or is produced by the loose bodies is not always definite. There is very little question, however, that some loose bodies are produced, particularly in elderly persons, by the marginal osteophytic growths in marked cases of hypertrophic arthritis breaking off and wandering about the joint and increasing in size (Fig. 6). Most probably the slight degree of hypertrophic arthritis seen in younger persons with loose bodies is secondary to the latter. It may be almost arbitrarily stated



FIG. 1.—Showing intimate relation of internal semilunar cartilage to internal lateral ligament and the lack of this relation of the external semilunar cartilage to the external lateral ligament.

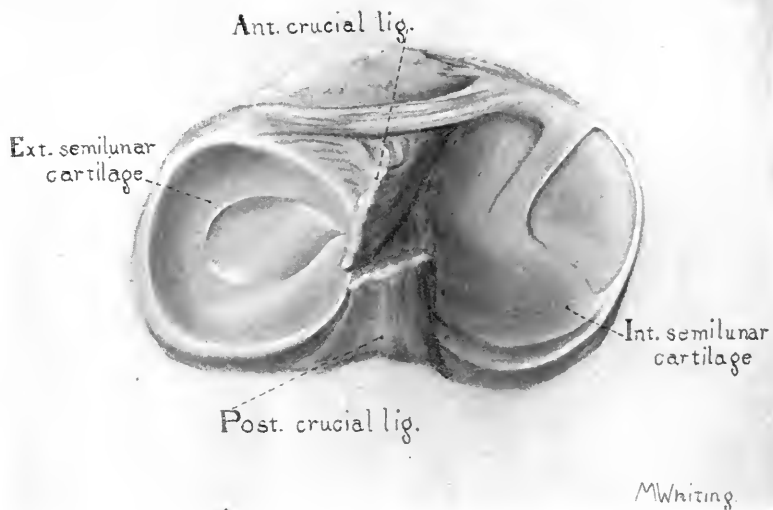


FIG. 2.—Showing internal semilunar cartilage displaced outwardly; anterior portion blocking extension.



FIG. 3.—Osteochondritis dissecans. Loose bodies arising from the internal condyle resting in the spot of its origin.

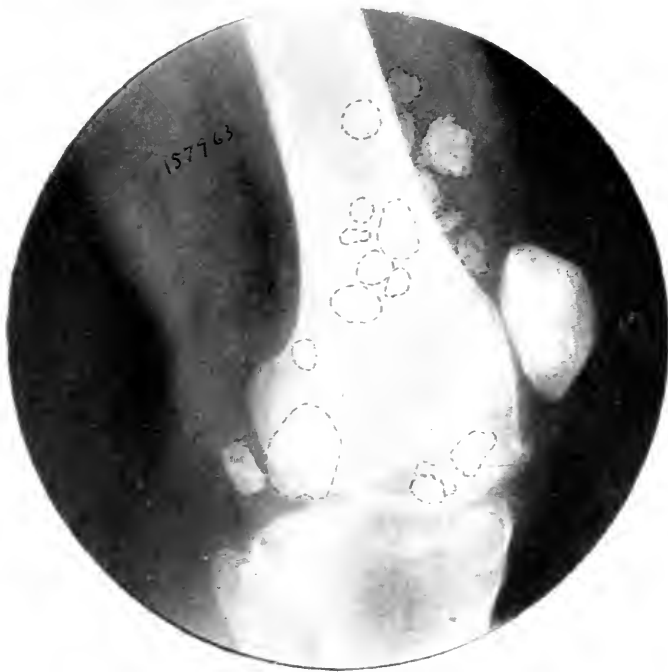


FIG. 4.—Osteochondromatosis of the knee-joint in which the loose bodies originate from the synovial membrane.



FIG. 5.—Osteochondromatosis associated with a malignant tumor of the lower end of the femur (sarcoma), later causing death.



FIG. 6.—Loose bodies due to osteophytic growths of hypertrophic arthritis.



## MECHANICAL DERANGEMENT OF THE KNEE-JOINT

that the presence of loose bodies demands their removal, the general condition of the patient being taken into consideration.

If the loose bodies are single or only a few, and are in the suprapatellar pouch, they may ordinarily be removed under local anæsthesia. The knee is carefully prepared, the skin and subcutaneous structures are anæsthetized, and the loose body carefully palpated and held firmly between the fingers. A sharp cutting needle is thrust through the skin directly into the body, thus fixing it securely. With a sharp knife, the dissection is carefully carried down to the body and it is removed. After this simple procedure, the patient may be permitted to walk the same day. When the body is situated in the middle of the joint, as definitely ascertained by the röntgenogram, usually in a notch or a depression in the internal condyle, the inner condylar incision, as used in the removal of the internal semilunar cartilage, may be employed. If, however, exploration of the entire anterior compartment is necessary, the patella should be split longitudinally, the fibres of the patellar ligament divided, and the fibres of the quadriceps split a short distance above the patella. If there are loose bodies in the posterior compartment some may be successfully forced through into the anterior section. This is not always possible, and it may be necessary later to enter the posterior compartment by a posterior incision. It has been our custom not to do this at the primary operation, but preferably about two or three weeks later, in the meanwhile not allowing any motion of the knee. The posterior approach is not easy, particularly if the patient is fat or very muscular. The incision is six inches in length, running down the middle of the popliteal space. The centre of the incision is located over the joint line. It is preferable to dissect down between the heads of the gastrocnemii so as to keep the nerves and vessels to the outer side. The popliteal muscle is dissected through, the ligament of Winslow is divided, and the joint entered. By slightly flexing the knee, the capsule is a little relaxed and curved forceps may be introduced. If the bodies cannot be removed in this way, it may be necessary to force them out by palpation both within and without the wound. It is not always easy to remove all of them.

Following operations on the front of the joint when the capsule is opened on the inner side or the patella split, a plaster-of-Paris case should be applied and worn, in the latter case for three weeks. When the posterior incision is used a case is necessary for a week only. Rupture of the crucial ligaments does not produce typical mechanical derangement of the knee. The disability, however, is extreme. If the anterior crucial ligament is torn, the slipping forward of the tibia on the femur will be permitted, whereas rupture of the posterior crucial ligament will permit a slipping backward of the tibia on the femur. Open operation for suture is not necessary. If the knee is placed in the normal or a very slightly flexed position in a case well padded to take care of the swelling, an excellently functioning joint will result.

CONCLUSIONS

1. Mechanical derangements of the knee are usually produced in the order named, by a damaged internal semilunar cartilage, by loose osteo-cartilaginous bodies, and by the external semilunar cartilage.
2. Loose bodies of extrinsic origin produce derangements but are not frequent in civil practice.
3. Loose bodies *per se* demand removal.
4. A patient giving a history of mechanical derangement owing to a damaged semilunar cartilage should not be operated, unless the locking is repeated or reduction cannot be accomplished in any other way.
5. In properly selected cases the operative results are excellent.

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# TRANSACTIONS

OF THE

## NEW YORK SURGICAL SOCIETY

*Stated Meeting, held February 27, 1918*

The Vice-President, DR. WILLIAM A. DOWNES, in the Chair

### REPEATED PERFORATION OF GASTRIC ULCER

DR. J. P. HOGUET presented a man fifty-two years of age, who came into the Hudson Street Hospital on March 20, 1917, with all the clinical symptoms and physical signs of a perforated gastric ulcer. He was operated by Doctor Turnure on the same day. The history of the operation states that the perforated ulcer was  $\frac{1}{4}$  inch in diameter, situated on the anterior surface of the stomach one and a half inches from the pylorus, with an indurated area of  $\frac{1}{2}$  inch surrounding it. The perforation was sutured with several layer-sutures of chromic gut. He made a perfectly good recovery and left the hospital on April 8th. He remained well until December 22, 1917, when he came into the hospital with the history that for a week he had been constipated, and at times dizzy; during these dizzy attacks he vomited, usually about two hours after eating. Also during these attacks, he complained of pain in the epigastric region referred to the angle of the right scapula. On the day before admission he had a severe attack. He was operated on the day of admission, as he had all the clinical symptoms and physical signs of an acute perforation of the stomach. A perforated gastric ulcer was found at exactly the same place as at the first operation. There was visible rather a wide area of cicatricial tissue and in the middle of this area was the perforation about  $\frac{1}{4}$  inch in diameter. There was a considerable amount of free fluid in the abdominal cavity and the perforation was closed and a gastro-enterostomy done in the hope that by this means another perforation might be prevented. His recovery was uneventful and he has remained well up to the present.

### CARCINOMA OF THE UNDESCENDED TESTIS

DR. J. P. HOGUET presented a man, aged thirty years, who was born with an undescended testicle. One year ago last April, he noticed a swelling in his groin; this swelling became painful after a few months and later there was no pain at all, but the size of the growth increased greatly. He was first seen in April, 1917, when he had a large tumor in the groin with an empty scrotum on that side. The tumor was freely movable and was not tender—the typical picture of a large tumor of an undescended testicle. Operated upon on April 20th, at the French Hospital. Tumor removed by

a high ligature of the cord. The pathological report was that the tumor was an embryonal carcinoma.

DR. WILLIAM A. DOWNES referred to a case in a man of forty-five years, with an undescended testis, who gave the history that he was able to push the mass into the abdomen easily. For twenty years he had been conscious of this condition and then the testicle gradually began to enlarge, forming a tumor the size of an orange which proved to be carcinoma at operation. Considering the case reported by Doctor Hugué, it raises the question whether a man entering the Army with an undescended testis might not later, from the various exercises, drills, etc., so traumatize the mass as to cause malignant change to take place.

#### RETROSTERNAL GOITRE

DR. J. P. HOGUÉ presented a woman who came into the French Hospital last April, with a tumor in the midline of the neck about an inch to an inch and a half above the sternum; he operated her at that time, thinking she had a simple adenoma of the thyroid that could be easily enucleated. A simple adenoma was found, but there still seemed to be something behind it, and, going further, there was found another tumor which was larger than the first, seated directly behind the sternum. Dr. James Ewing reported two separate tumor masses completely circumscribed: the smaller a simple adenoma; the larger entirely composed of colloid material.

#### CONGENITAL HERNIA OF THE DIAPHRAGM

DR. WILLIAM A. DOWNES presented a boy, seven years of age, who was admitted December 28, 1917, with the history that about five and one-half years ago he began to vomit almost immediately following meals. The vomiting was in periodic attacks lasting from two to three months with an interval of the same length free from any attacks; this continued until three and one-half years ago when he ceased vomiting for eight or nine months. During the nine months interval free from vomiting he gained rapidly in weight. Twenty months ago the vomiting began again with no free intervals except for a day or two, occasionally there was discomfort after eating and if vomiting did not occur he would bring it on by "putting his finger in his throat"; the vomitus was of food freshly masticated and in amount from about one-half to the entire meal.

When he was two years of age he fell down a flight of stairs. When admitted he was poorly nourished and undersized.

His chest was very long and narrow with very prominent ribs, poor expansion. Liver dulness to the fourth rib anterior right side; and the cardiohepatic angle obliterated, the posterior dulness of the liver reached the fourth intercostal space; otherwise lung signs clear. Heart—the apex in the fourth space just inside the nipple line; on percussion the cardiohepatic angle obliterated; tympanitic note at the third and fourth interspaces just to the left of the sternum; the heart dulness appears extending well beyond



FIG. 1.—Case of congenital diaphragmatic hernia. Male aged seven years. (Radiographed by Dr. L. T. Le Wald.)



## COMPOSITE TUMOR OF THE PAROTID

the nipple line, suggesting displacement of the heart to the right. Succussion sounds heard in the right lower chest on shaking. Abdomen scaphoid; walls soft; no masses felt. Skiagraph shown in Fig. 1.

On admission, blood count: Red blood-cells, 3,400,000; hæmoglobin, 65; white blood-cells, 6500; polymorphonuclears, 64; leucocytes, 36. Wassermann negative. Urine negative. Weight, twenty-four pounds.

During the first day postoperative the patient was in good condition, without distention, nausea or vomiting. On the second day a stomach lavage was given, with dark brown fluid return, and patient complained of some pain in the region of the wound.

Third day postoperative the stomach was again washed out, with greenish fluid return; relief of pain. Fourth day showed some distention of abdomen and patient still complained of pain in abdomen. Fifth day there were no complaints. Sixth day he complained of pain in abdomen and there was some subcutaneous emphysema noted along the right margin of the sternum; disappeared in about three days. Eighth day he was very comfortable and from then on complained of very little pain except some around the wound.

Weight on admission twenty-four pounds. By the fortieth day it had increased to thirty-two pounds. He was discharged in good condition and was able to eat with no vomiting.

DR. WALTON MARTIN stated that he had seen two instances of hernia of the diaphragm, both in adults; one was in a cadaver at the College of Physicians and Surgeons, some years ago, in which the stomach was in the left chest and the colon with the appendix was under the second rib. The second was in the service of Doctor Abbe, and the case was reported by Dr. Karl Vogel; in this instance the colon was also, with the stomach, in the left chest. Both patients reached adult life and both gave the appearance of being well nourished. The first was stated to have died of tuberculosis, the diagnosis having been based possibly upon the sounds heard in the chest emanating from the colon and stomach. The other patient had no digestive difficulty and died of peritonitis following diverticulitis of the sigmoid.

## COMPOSITE TUMOR OF THE PAROTID

DR. WALTON MARTIN presented a woman, fifty-four years old, who was operated on by him at St. Luke's Hospital in September, 1917. She was suffering at that time from a composite tumor of the parotid. The tumor was about  $2\frac{1}{2}$  inches in one diameter by  $1\frac{1}{2}$  inches in the other and presented the usual characteristics of this type of tumor of the parotid.

Under ether anæsthesia the tumor was removed through an incision following the outline of the posterior and inferior borders of the mandible and then dissecting up the skin sufficiently to expose the tumor imbedded in the parotid. The tumor and its capsule were removed at the operation. The wound healed by primary union; but after about ten days a soft, painful swelling made its appearance in the parotid at the part of the gland where the tumor had been removed. A needle introduced withdrew clear fluid,

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evidently saliva. In a week or ten days the fluid again accumulated and only finally disappeared after seven or eight weeks. She has also complained of paroxysmal attacks of pain in the parotid since the operation.

### GASTROSTOMY FOR CARCINOMA OF THE ŒSOPHAGUS

DR. JOHN ROGERS presented a man aged fifty years, who came to Bellevue Hospital in January, 1918, presenting the typical picture of an obstruction at the cardiac orifice of the stomach. This in a short time became complete, and on January 19, 1918, a Janeway gastrostomy was performed, and the condition ascertained by exploration to be a carcinoma of the lower end of the Œsophagus and the upper end of the stomach. This was inoperable. The gastrostomy was performed by cutting a rectangular flap three inches long and two inches wide at the greater curvature from the anterior surface of the stomach. The gap in the stomach was closed by uniting the sides of the two-inch gap and then folding the flap together in the shape of a cylinder. The cylinder connecting with the interior of the stomach was then turned out through a stab wound in the left rectus muscle, and sutured to the skin so that the mucosa projected a half inch beyond the skin surface. This gastrostomy does not leak, and if the bit of stomach projects far enough from the skin it does not close. A full description of the operation can be found in Doctor Janeway's original report.

### EXOPHTHALMIC GOITRE

DR. JOHN ROGERS presented the following patients:

CASE I.—Mrs. C. S., aged twenty-one, when first seen in July, 1911. She then presented a small cystadenoma of the lower pole of the left thyroid lobe 2 inches in diameter. The right lobe and the isthmus were perceptible only. She gave a history of having grown up rather rapidly, of always being tall and thin and easily fatigued, and on the least exertion or excitement complained of some breathlessness and tachycardia. When quiet the pulse and all symptoms were normal. Her chief complaints were frequent headaches, weakness and fatigability, and dry skin, constipation and gaseous indigestion. These were interpreted as evidences of hypothyroidism. Under thyroid feeding with tablets containing 2 per cent. of the coagulable thyroid proteins, she improved somewhat in strength and had less headache. Later, after stopping the tablets and undergoing much fatigue in rather strenuous household occupations, she suffered from a rather pronounced rapid pulse, loss of flesh, sweating and loose bowel movements. During this period there were no headaches. In other words, the chronic hypothyroidism was followed, in this case, after fatigue by a rather typical hyperthyroid disturbance, but without exophthalmos. By rest and medical treatment this gradually improved until the condition of constipation, headache and fatigability returned. In the intervening seven years until the present time she has repeated this story quite frequently. In other words, this patient is a chronic hypothyroid subject, but has suffered repeated attacks of hyperthyroidism. At present, she shows



## EXOPHTHALMIC GOITRE

a mild hyperthyroidism. The cystadenoma in the right lobe of her thyroid has gradually increased in size, and is now four or five inches in diameter instead of two. In these cases, the gland surrounding the capsule of the tumor should show the convoluted folds of epithelium in each acinus which are characteristic of the hyperthyroid disturbance. The gland, however, which is a little further removed from the tumor, should show only the slightly enlarged alveoli of a "simple goitre," and the excision of the tumor will cause all the hyperthyroid changes to disappear and she will resume her condition of mild chronic hypothyroidism, which is easily relieved by thyroid feeding. Apparently, as time goes on, the thyroid gradually becomes able to do its duty, especially if assisted by thyroid feeding, and she will eventually become a perfectly normal individual, although always having physical limitations which are connected with fatigue. Any extreme of work or worry will for many years give rise to symptoms which can only be interpreted as those of hypothyroidism.

CASE II.—Man, aged twenty-four years, was first seen in May, 1917. He gave a history of having studied very hard in preparatory school and in the City College, and of pain which began in the region of the thyroid, in 1911, and was intensified by work or study. The gland, in 1912, began to enlarge, and in 1913 he suffered from some tachycardia and some pain in his eyes. He apparently had a mild hyperthyroidism, with a slight enlargement of the right lobe of the thyroid and with more or less ache or a choking discomfort in this region. He was operated in August, 1915, at St. Luke's Hospital, and had the right lobe of the gland removed. The pain persisted in his neck, although the discomfort in his eyes and the tachycardia gradually disappeared in the course of the succeeding year. Ever since 1916, however, any considerable exertion either mental or physical increases this pain in his thyroid region, and he has noticed that his mentality has not been capable of prolonged work. That is, he cannot study or remember as well as he used to. Thyroid feeding with tablets containing 5 per cent. of the coagulable proteins seems to relieve this pain to a certain extent, but never completely except when his mind and body are entirely at rest. That is, fatigue of any kind seems immediately reflected to his thyroid region, and is manifested by a pain which he locates in the isthmus of the gland which is relieved by rest and thyroid feeding.

CASE III.—Man, aged thirty-three years, was first seen in December, 1915. Gave a history of hard work and attacks of sciatica with muscular weakness, which began in 1913. He first noted exophthalmos in May, 1915, and a little later a "goitre" was observed. He then spent several weeks in Roosevelt Hospital under medical treatment, and during the summer of 1915 went to the country and gained 40 pounds. After returning to work in the Fall, he lost this weight and several pounds in addition. In December, 1915, he presented himself with marked exophthalmos and perceptible thyroid enlargement, a blood-pressure of 140, a pulse-rate of 100-120, a weight of 106, and rather pronounced emaciation with a fine tremor in the extended fingers. The skin was

pale and dry, the bowels constipated. Sympathetic atonia. An experimental test with thyroid feeding intensified all his symptoms. He was then put through the calorimeter by Doctor DuBois, in Bellevue Hospital, and was found to have a normal metabolism. That is, the best test known for hyperthyroidism showed that that condition did not exist. In spite of these findings, on December 31, 1915, Doctor Rogers ligated both superior thyroid vessels and excised for examination the tips of both lobes. The report which came back from the pathologist was "simple goitre. No hyperthyroid changes to be found." Very little improvement followed the ligation until a month later, when feeding with the adrenal proteins was begun. In March, 1916, the pulse was still 100-120, but the weight had increased from 106 to 134. In October, 1916, after six months rest in the country, the weight had been changed, but the subjective symptoms had been decidedly improved. The nervousness and fatigability were much less. In July, 1917, the condition was about as at present, which means that he still presents some traces of exophthalmos; the strength is good, but he cannot undergo much nervous or physical strain without an undue amount of fatigue. This case was one in which excision of the thyroid would have resulted in a hopeless condition of asthenia.

DR. WALTON MARTIN said he could throw light on one of the cases presented by Doctor Rogers. He had performed a hemithyroidectomy about two and a half years ago on the patient. The indication for the operation was persistent pain in the midline of the neck and an enlargement of the thyroid on the right side. The pulse-rate was never more than 100, he had no evidences of exophthalmos, or other signs of hyperthyroidism. He made a good recovery after the operation. His pulse was 72 on leaving the hospital. Microscopical examination showed colloid adenomatous goitre. He continued to complain of pain in his neck, however, and a variety of neurasthenic symptoms. From time to time he had written long, rambling letters explaining his ailments. These letters suggested an unbalanced mentality. He had referred him to Doctor Rogers thinking treatment by organ therapy would do him no harm and might give him mental relief. As to Doctor Rogers' statement that hemithyroidectomy might do harm by inducing hypothyroidism, he had not personally seen clinical evidence which bore out this statement, certainly one saw very striking improvement and gain in weight after partial thyroidectomy in suitable cases of toxic goitres. Reports from large clinics like the Mayo's showed favorable results, that is, about 75 per cent. of those operated on report themselves as cured.

DR. JOHN ROGERS, in closing, called attention to the fact that he did not mean that a great many cases suffered from hypothyroidism as a result of the operation, but that a good many died immediately from the effects of the operation. There are some cases in which the results were not satisfactory, *i.e.*, where the symptoms continue and where new ones develop and the patient is then classed among the neurasthenics. He suggests that when one is in doubt as to what is going to happen in any case referred to him, he would be safe to tie off the four thyroid arteries.

## MAJOR OPERATIONS UNDER LOCAL ANÆSTHESIA

*Stated Meeting, held March 13, 1918*

The Vice-President, DR. WILLIAM A. DOWNES, in the Chair

### MAJOR OPERATIONS UNDER LOCAL ANÆSTHESIA

DR. JOSEPH WIENER presented a man of sixty-five years, who was operated on at Mt. Sinai Hospital in February, 1918. The abdomen was opened by a transverse incision across the rectus and upper part of the abdomen; the gall-bladder was found considerably enlarged with the omentum wrapped around it; the cystic duct was tightly strictured. The gall-bladder was removed, common duct opened, and a stricture found which was cut and then a little wick of rubber drain was put down to the opening in the common duct after putting a fine catgut suture in the wall of the duct. The abdomen was closed in layer sutures. Operation took forty-five minutes. This gall-bladder contained stones and so did the cystic duct. The patient had very little pain, all manipulations were made without any difficulty, and he made an uneventful recovery. He still has an opening in one angle of the wound but there is no more bile coming from it.

This is the first choledochotomy that Doctor Wiener had done under local anæsthesia, although several cholecystectomies and cholecystostomies had been done. The technic was somewhat varied in this case and it was found that the patient had pain when the gall-bladder was pulled up with the clamp from the liver bed. Therefore the local anæsthetic was injected between the liver and the gall-bladder, then into the cystic duct and around the neck of the gall-bladder. This patient, although he stood the forty-five minutes of manipulation under local anæsthesia very well, would not have stood forty-five minutes of ether anæsthesia.

As regards the preparation of patients, it is Wiener's rule to administer two doses of morphine in divided doses,  $\frac{1}{4}$  of a grain being given by a hypodermic thirty minutes before the patient comes to the operating room and  $\frac{1}{4}$  of a grain after reaching the anæsthesia room. With one exception every adult has required a second quarter grain of morphine and it is given in divided doses to exclude any possibility of idiosyncrasy to the drug.

This operation was done under apothesine. Apothesine and novocaine belong to the ester group; both have an amido base; novocaine is made with ethyl alcohol and apothesine with propyl alcohol. Both novocaine and apothesine are non-toxic. As regards the percentage of the solutions, 1 per cent. is that advocated by Doctor Wiener, and to this he usually adds adrenalin to prolong the anæsthesia. In some cases he has tried using salt instead of adrenalin, but it does not work so well. As regards the amounts, he has repeatedly used twelve grains of both novocaine and apothesine without any noticeable effects. He cited a rather striking example of the non-toxic effect of novocaine in a patient with appendicitis with perforation and peritonitis: A solution had been given to the patient to drink, that is, six

grains of novocaine were in the patient's stomach and he then used six grains under the skin without the slightest sign of any irregularity of the pulse. The amount of adrenalin used in an ounce of a 1 per cent. solution would correspond about to ten drops of the one to one thousand solution.

As regards the time of operation for local anæsthesia, it does take longer than under general anæsthesia, but the patients stand it very well.

In regard to the time that local anæsthesia will act, it has been the general impression of Doctor Wiener that apothesine lasts longer than novocaine, although he has nothing to prove this belief. He has done a radical breast amputation taking over an hour, using the transverse Stewart incision, and there was still skin anæsthesia at the end of the operation. On several appendectomies, however, he has found that the skin anæsthesia has gone after the expiration of thirty-five minutes.

One satisfactory thing about apothesine is that it can be obtained in this country, being made by Parke, Davis & Co., and can be purchased in tablets of  $1\frac{1}{4}$  grains which require only three or four tablets for a major operation.

As to the amount of the solution used, Doctor Wiener states that in an ordinary appendectomy he can get along with one ounce; for a hernia with less than an ounce; for breast amputation it requires sometimes as much as three ounces of the solution.

DR. WILLIAM A. DOWNES stated that he had used a great deal of local anæsthesia, both novocaine and apothesine, but has not used adrenalin for several years, due to the fact that he found when using adrenalin there was apt to be some sloughing of the margins of the wound. He considers his results without the adrenalin quite as satisfactory as with it, so far as the anæsthesia goes.

#### COMPOUND FRACTURE OF BOTH BONES OF THE LEG WITH AMPUTATION

DR. SETH M. MILLIKEN presented a man who was admitted to Lincoln Hospital on June 25, 1917, having been knocked off a motor cycle by an automobile. He was put to bed, his fracture put up by the house staff of the hospital, and X-ray taken the next day failed to show perfect position of the fragments, therefore under ether anæsthesia reduction was done, cleaning out the wound, and partially closing it with one stitch. Splints were re-applied. Temperature rose to  $100.5^{\circ}$  and there was a great deal of hæmatoma and swelling below the site of fracture. On the following day his temperature was  $102.6^{\circ}$  and he was delirious. There was marked interference with circulation of the foot: the bandage was removed, the foot elevated, and the next day the temperature was  $103^{\circ}$  and there was obstruction in the circulation to the foot. A circular disarticulation at the knee-joint was done and he ran a very septic course, with induration half way up the thigh. He developed an erysipelas which started in his thigh, jumped to his face and extended all over his body with periphlebitis and abscess

## SUPPURATIVE NEPHRITIS WITH CALCULUS IN URETER

formation over the condyles and scalp of the back of his head. A pocket was opened in the joint cavity above the patella on July 16th. He was delirious and in bad shape until July 21st, one month after admission. At this time heavy granulations covered the stump except over the cartilages of the condyles of the femur. On September 24th the epithelium had covered in the granulations up to the margins of the condyles. An aperiosteal amputation was done on September 24th, a little below the middle of the thigh, and the flaps loosely approximated. A rubber tissue drain was placed at each angle and a dry dressing applied. There was practically primary union. He now has developed a bursa over the inner margin of the femur and can bear his entire weight on the stump. He will be able to use a properly made artificial leg. He was terribly septic and it is very gratifying to obtain end-bearing stump.

## DOUBLE NEPHROLITHIASIS

DR. ALLEN O. WHIPPLE presented a woman, aged twenty-eight years, who was admitted to the Presbyterian Hospital December 15, 1917, complaining of pain in both lumbar regions, but most pronounced on the right side. Skiagraphs showed calculi in both kidneys. Catheterization of the ureters gave purulent urine from the left kidney, clear urine from the right. On December 21, the right kidney was exposed and opened and four calculi, each in a separate calyx in the lower half of the kidney, were removed. Operative recovery was uncomplicated, and on January 31, 1918, six weeks later, the left kidney was operated on. It was found in a condition of pyonephrosis and was removed *in toto*. She made a smooth recovery. The urinary output was abundant. She was discharged on the seventeenth day after this operation.

## SUPPURATIVE NEPHRITIS WITH CALCULUS IN URETER

DOCTOR WHIPPLE also presented a man, aged thirty-three years, who was admitted on account of persistent pain in the right lumbar region, with tenderness and septic symptoms. An intermuscular incision, through the McBurney point, showed a normal appendix, but with a cæcum in the region of the liver. In the region of the kidney, however, was considerable induration and the right kidney was enlarged. On approaching the right kidney through lumbar incision, the posterior fatty capsule was found greatly thickened, indurated and soggy. Near the pelvis, posterior aspect, there was a gush of blood-tinged fluid which appeared when the indurated capsule was broken into. The true capsule was not adherent except at one place in the lower pole of the kidney, posterior aspect, where there was a small softened focus, but did not contain pus. The entire kidney, except for enlargement and the one focus, looked normal, and exploration with a needle disclosed no stones. It was thought advisable, in view of not knowing the

function of the left kidney, to do no more than drain the right one by nephrotomy. A subsequent skiagraph revealed a calculus in the ureter at the level of the transverse process of the fourth lumbar vertebra. At a second operation the ureter was exposed by mobilizing the ascending colon. The only way in which the pelvis and ureter were found was by identifying the lower pole of kidney and duodenum. The stone,  $2 \times 5 \times 3$  mm., was rough, dark, and impacted in the first centimetre of the ureter. It was with difficulty disengaged. Urine followed from ureter as soon as it was removed. Vertebrated probe passed down and up ureter easily. Twenty-five days post-operative there was damming back of pus in anterior wounds, so they were enlarged under gas. Meatotomy next day after a ureteral catheterization which showed retention of cloudy urine in pelvis of right kidney. Repeated fourteen days later with same result. Recovery stormy. At the present time, there are no urinary disturbances and his general condition has greatly improved.

DR. WILLY MEYER stated that frequently nephrolithiasis is found to be bilateral. The question will arise, if we have a nephrolithiasis plus stone in the ureter on one and the same side, or nephrolithiasis on one side and stone in the ureter on the other side, which of the troubles should be operated upon first? He suggests that the calculus in the ureter should always be the one chosen for the first operation, provided the patient is unable to stand both on the same side in one stage. When the operation on the kidney substance is undertaken at the second stage, there will be a functioning ureter to rely on.

Doctor Meyer considers the reported case of suppurative nephritis with calculus in the ureter as of particular interest, as the complications might have occurred in any case where one is called upon to operate suddenly on a patient stricken with chills and high fever and where suppuration in the kidney is diagnosed. He stated that a number of years ago, when X-ray work was in its infancy, he had such a case under his care; this was a woman who had been taken sick sometime before with acute renal colic and then stricken with chills and fever running up to  $105^{\circ}$  and  $106^{\circ}$ , showing great tenderness on lumbar palpation. Undoubtedly there was unilateral acute renal infection. There was no time for radiographic and cystoscopic examination. He therefore cut down on the kidney primarily and found a number of larger and smaller abscesses throughout the parenchyma of the kidney which showed the colon bacillus in pure culture. Not knowing the function of the other kidney, he of course could not remove this kidney. He therefore made two-thirds of a section cut of the central part of the organ. Having entered into the pelvis he kept the two halves separated by a drain and several tampons. To his astonishment, this patient pulled through with a well functioning kidney. X-rays and ureteral catheterization done later demonstrated, as cause of the disease, a stone in the ureter wedged in where the uterine artery crosses the ureter. When this stone was removed the kidney drained normally.

## CHLORINE ANTISEPTICS IN CIVIL HOSPITAL USE

### THE USE OF CHLORINE ANTISEPTICS IN CIVIL HOSPITALS

DR. JOHN A. HARTWELL read a paper with the above title, for which see page 385.

DR. A. V. S. LAMBERT stated that the Dakin fluid had had certain advantages which Doctor Hartwell had brought out clearly in the action that it has on dead tissue in the wound which none of the other antiseptics or fluids now used for bathing wounds possess. His experience with traumatic cases has been very satisfactory and the problem here is one of placing the tube in such a way as to have the fluid bathe the tissues. A problem which has particularly interested Doctor Lambert has been the application of this fluid to the infections that are due to bacterial invasion coming from the blood stream or from the intestinal tract or some other avenue rather than from a visible large lacerated wound. He stated that a considerable number of osteomyelitis cases had been treated this winter with this fluid and the impression has been that suppuration is controlled better by the use of the Dakin solution than by any other method up to the present time. The bone is not bathed so continuously in purulent fluid and there has not been the progressive necrosis or the formation of small sequestra to the same extent as in cases before the use of this fluid. Doctor Lambert considered Doctor Hartwell's suggestion that possibly the result might be just as good if the same amount of trouble were taken with other material as that expended when Dakin's solution was used, one which might bear investigation. There is one point about the dressings to which he called attention; that is, after the third day they are practically painless. The dressing can be carried out with much less discomfort to the patient than under the old form of packing and removing of drains of gauze or other material. The patients suffer less under the treatment and in osteomyelitis cases it has been particularly noticeable.

At the Presbyterian Hospital Doctor Rulison has started in to treat appendix cases with abscess and the problem he has been working on is the action of this fluid in the peritoneal cavity and the possibility of introducing it to the depth of the wound in the presence of rather recent adhesions thrown out about a tube or drainage. In a few cases which he has been studying, he has met with success. He has attempted a different arrangement of tubes which will ensure the free exit of the fluid, and a temporary bathing of the wound rather than puddling the fluid in it.

Doctor Lambert stated that he had used this fluid in wounds resulting after the section of the large intestine where instead of sewing up immediately the superficial subcutaneous tissue and skin he left it open, put the tubes with the fluid on them and by this treatment prevented suppuration in these wounds.

He has not had a great deal of experience with dichloramine-T. He considers it a less effective dressing in wounds where suppuration and inflammation is well established.

DR. WALTON MARTIN stated that to understand the value of the Carrel-Dakin treatment one must keep in mind that two distinct processes are employed. First, there is the mechanical cleansing of the wound if contaminated or the necessary surgical procedure in well-established infection; and second, the application of the antiseptic according to carefully thought out rules.

In a recent gunshot injury, if the necrotic and devitalized tissue along the entire track of the missile is excised, the wound is changed from a heavily infected lacerated contused wound to an incised wound slightly infected. Carrel gives the credit for first carrying out this excision to Depage and his school, and from results published by Depage convincing evidence is given of its importance. In gunshot injuries of the knee, for example, Depage reported that from 1915 to 1916 he used the complete technic as advised by Carrel and he had far better results than before its use. After July, 1916, however, after excision of the bullet track, he systematically adopted immediate closure of the wound track even in cases of extensive osseous lesions, and no antiseptics whatever were used, and yet since he had adopted this method his results had been far better than when he used the full Carrel treatment—80 per cent. recoveries with restoration of movement, whereas under the Carrel-Dakin method he had only 40 per cent.

But in treatment of fractures of the long bones he has followed with excellent results the full Carrel method. In 1917 he reported 75 cases closed secondarily after treatment from fifteen days to a month. The regular introduction of the Dakin solution possibly aids in the elimination of areas of necrotic tissue and minute foci of infection which might readily escape detection in the excision of the tissue about the entire bullet track in these extensive injuries.

In regard to the introduction of this method where infection is well established in civil hospitals, Doctor Martin called attention to the well-known fact pointed out by Doctor Carrel himself, that no antiseptic can possibly have any bactericidal property unless it comes in intimate contact with the microorganisms. This is well exemplified in the treatment of long established suppurative osteomyelitis; the Dakin solution simply keeps the wound surface clean, cleaner than any antiseptic Doctor Martin had ever seen used, but unless the treatment was joined with well considered surgical procedures it must necessarily be ineffective.

Doctor Martin once more emphasized the two essential features: first, the mechanical procedure according to generally recognized principles of surgery; second, the systematic flushing of the wound with the Dakin solution, the latter in many instances a very valuable adjuvant.

DR. ALEXIS V. MOSCHOWITZ stated that up to the early part of last summer he, after having tried out as he considered faithfully, the Carrel-Dakin technic, had abandoned it because of his extremely poor results.



## CHLORINE ANTISEPTICS IN CIVIL HOSPITAL USE

He, however, went to the Emergency Hospital shortly after it was opened and there learned that his results had been poor because he had not understood the technic as it should be employed. Since that time he has again used it at Mt. Sinai Hospital and is now a decided advocate in its behalf, believing it to be a most excellent treatment. He described three cases of osteomyelitis in which excellent results were obtained, several cases of abscess of the breast and some instances of other subcutaneous abscesses and infections of various kinds.

DR. WILLIAM A. DOWNES inquired if Doctor Lambert in the use of this method in abdominal sinuses had experienced the formation of fecal fistulæ. He referred to an instance in which dichloramine-T was injected into the sinus of an old suppurating abdominal wound where the intestines had not been at all injured at the time of operation and where in the course of two or three weeks a fecal fistula developed. He also had heard of one or two other similar instances and questioned whether the selective action of this fluid for necrotic tissue was responsible for this result.

DR. A. V. S. LAMBERT in reply to Doctor Downes' query recalled a case of large intestine resection drained in the ordinary way to the site of the anastomosis. The resection of the transverse colon was done for carcinoma and the drainage was removed on the sixth day, remaining out for two days. At this time suppuration occurred and a small tube was again inserted through the sinus and Dakin's solution run in; the following day there was a fecal fistula and this he considered possibly due to the use of the Dakin fluid. He believed that Doctor Martin had had a somewhat similar instance in a case of a deep intestinal wound where two or three weeks after sloughing and the development of a small hole in the intestines resulted in a fecal fistula. He calls attention to the point that in these cases the Dakin solution lies in a deep pocket in the bottom of the wound where it has a chance to act in a way that it would not under ordinary circumstances. Its contact with soft tissue, such as coils of intestine, held together by fibrin in the early stage of repair, affords a possibility for absorption of the plastic exudate which has not become vascularized, and this results in the formation of a fecal fistula.

DR. F. S. MATHEWS referred to a case where he had somewhat contrary experience. This was in an acute appendicitis operated upon a year ago and which six weeks ago returned to him with the story that a sinus had persisted ever since his operation with discharge of abundant pus; he thought this might be due to a sponge having been left in the wound and on this supposition he had to do quite an extensive operation to expose the site of the trouble: He was unable to find any definite cause for the discharge except that the small intestine showed definite miliary tubercles. He closed the opening in the cæcum, placing a drain to the bottom of the cavity, but feared a fecal fistula, as he had practically done nothing except to enlarge the opening. Ten days or two weeks later he injected

dichloramine-T and finds that at the present time the man's wound has nearly healed and he is in excellent condition.

DR. J. A. HARTWELL, in closing, stated that they had had something over two hundred cases that could duplicate in every respect all those mentioned in the discussion. He purposely said nothing in his paper relative to the technic beyond stating that at Bellevue they had followed in every detail the Carrel technic. He considered that the failures were due to the presence of necrotic tissue at the bottom of the cavity. No antiseptic will do any good in such instances. He also called attention to one very noticeable failure in a boy with a bad trauma on the inside of the thigh which was cleaned up thoroughly and the Dakin treatment started. At the time of admission he had a very severe lymphangitis and at the present time is dying of a general septicæmia; the treatment with the Dakin solution did not in any way prevent the entrance of the bacteria into the blood. He mentioned another case of a fecal fistula in a tuberculous kidney where it was impossible to determine whether he was dealing with a perforated diverticulum or kidney tissue. The kidney was cut out and the wall of the descending colon exposed, and the patient developed a fecal fistula due to the packing used to control the hemorrhage. The Dakin solution kept the wound externally clean. It was a large open wound and as far as the action of the Dakin solution on the intestine was concerned it kept the fecal passage clean. This fistula was later curetted and healed. The hypochlorite solution only acts as such on any tissue where it comes in contact for six or eight minutes. It was found in filling a cavity with this solution that the action was practically *nil* at the end of seven minutes. It is then converted into the dichloramine which exists for possibly two hours. Then the hypochlorite solution is again injected. Its action is explained by the fact that it kills the bacteria on the surface, prevents recontamination, and when the dichloramine is formed it calls out the body defenses, bringing out the blood and the leucocytes and the fluid antibodies. In so far as it does this, it is the most ideal antiseptic we have. He then cited one or two instances of fecal fistula treated with dichloramine-T, calling attention to a case of fecal fistula following resection of the cæcum for carcinoma. This had apparently healed well but a sinus burrowed under the abdominal wall. This was cleaned out entirely and dichloramine was dropped in by using a pipette and the opening in the cæcum healed with great promptness. Another case was one where a fecal fistula persisted for eighteen months after operation. A long sinus was dissected out and only a thickened fibrous cord found and dichloramine-T was put into it with very prompt healing.

In closing his remarks Doctor Hartwell wished again to emphasize the points which Doctor Martin had brought out and to state as before that every detail of the Carrel treatment was carried out according to his technic. It cannot be hoped that this antiseptic will do any good unless the proper surgery is done to begin with.

## RESECTION OF STOMACH FOR ULCER

*Stated Meeting, held March 27, 1918*

The Vice-President, DR. WILLIAM A. DOWNES, in the Chair

### RESECTION OF STOMACH FOR ULCER AFTER POLYA-BALFOUR METHOD

DR. HERMANN FISCHER said that Polya, in 1911, described an anastomosis between the intestine and the stomach, side-to-side and retrocolic. Balfour has modified the method by using the anterior gastro-enterostomy, taking a long loop of the jejunum. Doctor Fischer has used this method in four cases and has been much pleased with the result. He stated that the whole incision of the stomach can be united to the jejunum, or only a part of it, using only the lower half of it if so desired. He has had three cases with good results and now presented a case in order to get the opinion of others in regard to the method. The patient presented was suffering from a peptic ulcer; an X-ray picture showed that he does not even now completely empty his stomach after six hours, but it has been noticed that after gastro-enterostomy there is often some insufficiency in motility of the stomach without giving the patient any discomfort.

He called attention to a technical point which was to make the muscularis suture attaching the jejunum to the stomach before cutting off the stomach. In his first case he put on a large clamp and had some trouble in inserting his first row of sutures, but with this precaution he believes the operation will be made much simpler and more satisfactory.

DR. WILLY MEYER stated that he had had occasion to do the Polya-Balfour method three months ago in a patient who evidently had a chronic ulceration at the lesser curvature attached to the lower part of the liver. She had suffered intensely for months and was operated upon by means of midresection of the stomach. The proximal stump was short, also the distal; end-to-end union out of question; also osteoplastic resection of the costal arch in order to facilitate the technical procedure. In this case Doctor Meyer followed the Polya-Balfour method, taking a coil with a long mesentery, perhaps two feet from the entrance of the jejunum into the general cavity, and turned this over the omentum and transverse colon and attached it to the cut in the stomach. The stomach wound was oblique and the anastomosis fully six inches long. This patient made the smoothest imaginable recovery. There was no vomiting after the second day. He believes the explanation of this is that the jejunum, having been anastomosed in such a way that its afferent part is attached to the lesser curvature, and naturally the efferent to the major, will push down till all the food is put into the stump of the stomach. Doctor Meyer believes Doctor Balfour's modification of the Reichel-Polya anastomosis will be of great service in many cases.

## NEW YORK SURGICAL SOCIETY

### SUCCESSFUL REMOVAL OF BREAST, UTERUS AND KIDNEY IN THE SAME PATIENT

DR. W. S. SCHLEY presented a woman who was admitted September 20, 1910, operated September 21, 1910, discharged October 25, 1910.

About six weeks before her entrance she noticed a mass the size of a walnut in right breast, outer hemisphere. It had increased in size up to admission. Axillary glands palpable, supraclavicular negative. Complete amputation with grafting. Glands not involved.

Four years later, September 1, 1914, she was admitted again with a general friable cauliflower growth of the cervix uteri, with extension to vaginal wall on right side. There appeared to be an extension of infiltration from cervix laterally into both broad ligaments. No enlarged lymphatics palpable. Operated September 4, 1914. Pan-hysterectomy; extensive dissection carried up to iliac glands and uterus and vaginal vault removed *en masse*. Following operation there was no urine passed and cystoscopic examination with ureter catheterization showed both occluded about 5 cm. from bladder. The abdomen was opened again under gas-oxygen anesthesia and it was found that, curiously, the ureters had been caught by the continuous whip stitch closing the peritoneum over the operative area—great care had been taken on account of the extensive dissection to identify the ureters throughout the operation, but on account of the removal of the vaginal vault and deep suturing they were both picked up in the closing stitches. It was a simple matter to release the obstruction. The following day 34 ounces of urine were passed. The fourth day following operation urinary leakage appeared in the vagina with the serous drainage, although it could not be demonstrated on releasing the ureters that they had been wounded by suture needle. It was determined again that there was partial obstruction of right ureter 10 cm. from bladder. Notwithstanding urotropine and soda benzoate and other measures, the patient developed a pyelonephritis inaugurated by a chill on the ninth day. The condition never entirely subsided and because of the urinary findings nephrectomy was done about two months later. The patient has been in perfect health since her discharge from the hospital. It is to be regretted that the wound in ureter was not recognized at the time of its release and bladder implantation done. Following the urinary leakage the ureter and kidney infection developed so quickly that we were forestalled in that direction. It is now nearly four years from the last operation and eight from the first, but there have been no signs of recurrence in either field.

### WIRING OF FRACTURED OLECRANON

DR. WILLY MEYER presented a man of fifty-six years who fell on his right elbow, sustaining a transverse fracture of the olecranon with capsular tears. Open treatment was decided on, March, 1916. It is important when intending to wire to allow the patient to wait about a week, even when one

is sure of the asepsis in the operating room. At the expiration of this time the lymph stomata have become clogged and there is less possibility of infection during the operation. With a convex incision this olecranon was wired just as a patella is wired. The man has obtained a good function. Doctor Meyer is a firm believer in the use of silver wire and has adhered to it in a series of over eighteen cases of patella fracture. The objection frequently voiced in regard to it, that it sometimes acts like foreign body, he has seen exemplified when the alloys of silver have been used; so he therefore uses only pure silver wire. He mentioned the possibility of refracture when using kangaroo tendon or chromic catgut, especially when the fragments are not brought into perfect apposition.

DR. LUCIUS W. HOTCHKISS stated that he has seen some of these cases suffer from too early attempt at passive motion. If the olecranon is sutured and put up at a proper angle of flexion it will stay, but too early attempt at passive motion may tear through the suture. The fine silver wire also may break or tear through. He has found less difficulty if manipulation is left until later and always puts the elbow up in flexion.

DR. J. M. HITZROT said that he began passive movements of the elbow in his cases of fracture of the olecranon at the end of ten days, very gradually increasing the arc of motion and being careful to do so within the limits of pain. He considered the use of wire as unnecessary. The problem is quite similar to that in fracture of the patella. When the expansion of the triceps tendon is torn, separation of the olecranon fragments must be overcome by direct fixation and suture of the torn expansion, as in the patella fracture. Doctor Hitzrot could not use the term "perfect result" as applied to Doctor Meyer's case, as the man shows a distinct loss of power in extension, and a loss of about 10 per cent. of the arc of complete extension. Loss of the power in complete extension occurs in practically all of these fractures and complete extension is rarely obtained.

In all his cases, Doctor Hitzrot used a kangaroo tendon suture passed through the triceps tendon close to the olecranon, and fastened to the ulna below the fracture by passing it through drill holes in the bone. When this is drawn taut, the fractured surfaces come into complete apposition and remain there. The torn expansion is then approximated by chromic sutures and the arm put up in extension with an anterior moulded plaster splint.

With regard to Doctor Meyer's statement regarding silver wire, Doctor Hitzrot could not agree.

After much investigation, Doctor Hitzrot found the brown iron wire used in the trade to bind bales of hay, brooms, etc., to be the strongest, cheapest and most serviceable. It is a malleable wire and comes in different sizes. It causes no more irritation than the more expensive wire, and, when required, will stand a very much greater strain than any of the other varieties, including the galvanized wire. Doctor Hitzrot has one case in a fracture of the humerus in which two pieces of wire have remained buried in the bone for a period of over six years without causing any

difficulty. In animals, the wire has exhibited exactly the same amount of irritation as is shown by silver, copper, and various alloy wires.

DR. ROBERT T. MORRIS inquired as to the formation of general adhesions in these joints with a resulting ankylosis, and stated that he in several instances had thought it necessary to inject artificial synovial fluid into these joints to overcome such adhesion.

DR. ROYAL WHITMAN thought that after suturing the olecranon, unless there were indications to the contrary, the arm should be placed in right angular flexion at the elbow. This attitude is more comfortable for the patient. It lessens the danger of œdema of the hand and it permits some functional use during the period of repair.

DR. WILLY MEYER, in closing, stated that he considered the question of after-treatment of vast importance. He believes the open operation in fracture of the olecranon or of the patella is frequently absolutely necessary to remove the interposition of a piece of tendon or periosteum which prevents the thorough approximation of the two fragments in many instances. In wiring these fragments of patella or olecranon he does not, however, believe in placing too much reliance upon the strength of the wire as such, and has therefore always followed the rule to first get healing of the fracture, with the extremity in extended posture,  $180^{\circ}$ , allowing say four weeks for such healing to take place. The bony callus will by this time hold the two fragments firmly fixed. At the end of four weeks he allows a patient with patellar fracture to get up, and begin active and passive motion. The latter is also done in cases of olecranon fracture. With patience they finally obtain perfect motion or at least useful limbs. With a perfect healing of the fracture assured, he believes it takes from three to four months before these patients get perfect extension and flexion.

Doctor Meyer said in response to Doctor Whitman's questioning, he relied upon the final result in a fracture, and whether of the olecranon or patella considered that this should be the criterion. He believes that after wiring a fracture the extremities should be put up in a position where there is no tension and for this reason he uses the extended position and is perfectly satisfied if the patient after three months gets perfect function or a useful limb rather than to put them in flexion and attempt to get motion in three weeks. He agrees that when they are put up in the right angle position it may take less time to get proper function. But perfect bony union may not have been obtained in the flexed position of the limb. The *final* result is the one to be worked for.

In answer to Doctor Morris' question he stated that as far as he knows ankylosis of the joint is principally caused by the amount of blood remaining in the joint; if at operation all liquid and coagulated blood is removed from the joint no ankylosis should occur. Naturally, there will be frequently some stiffness from non-use. Practical results, however, show that the four weeks rest does not interfere with the final good function of the arm or leg.

## APERIOSTEAL AMPUTATION STUMP

## APERIOSTEAL AMPUTATION STUMP

DR. WILLY MEYER presented two men who had suffered from thrombo-angitis obliterans. One, thirty-three years of age, had been treated at the Post-Graduate Hospital where his femoral vein had been tied by Doctor Heyd. He had had a necrosis of the metatarsal bone of the small toe. When he came under Doctor Meyer's observation he still had a great deal of pain, particularly during the night, and after having treated him with hypodermoclyses for some time and the wound not improving, Doctor Meyer re-operated on the metatarsal bone, although he had little faith in the procedure. The patient's foot showed no tendency to heal. After a while amputation was called for, although the pains were much less severe. Doctor Meyer made use of the aperiosteal method, viz.: instead of forming a periosteal flap as formerly done, the bone is sawed through beyond the periosteal division. About an inch and one-half of bone is left bare of periosteum and this part of the medulla of the bone is scraped. Then these patients later have an absolutely painless stump which is end-bearing.

The second case was a man thirty-eight years of age who came under Doctor Meyer's care in May, 1916, for the same trouble. At that time there was gangrene of the big toe, and after the use of hypodermoclysis of Ringer had brought some relief, there was still so much pain that removal of the toe was indicated. The patient was advised at this time to have a thigh amputation, but this he refused. He showed little, if any, improvement, and ligation of the femoral vein in Scarpa's triangle was done on May 25, 1916. The toe with a portion of the metatarsal bone had also been removed a few weeks previously and the patient returned home; but the wound did not heal. Three weeks later amputation of the thigh became necessary. The same procedure was followed as in the former case, and also, making rather large skin flaps should a part of them become necrosed. After eight or ten weeks the patient was discharged with a small sinus. Three months later the latter was still present and prevented the use of a peg-leg. He then developed an acute lymphangitis, and inside of a week the sinus which had persisted for weeks and weeks closed spontaneously, an observation which Doctor Meyer has had in a similar case before.

With regard to the construction of the peg-legs used temporarily, Doctor Meyer stated that each one naturally is somewhat different. The benefit from the new construction of artificial limbs is that the patient now *stands* on two legs instead of riding on his pelvis and swinging the stump of the amputated leg. In the second case just reported there is the same condition in the other foot which makes it impossible for the patient to walk very far.

A woman was presented who had suffered with a tuberculous inflammation of the right tibiotarsal joint, this inflammation having lasted six years. Unfortunately, there was alongside one of the tendons an ascension of the

tubercular infection to the middle of the leg. Doctor Meyer amputated the tibia and the fibula, leaving an aperiosteal stump on both bones and using secondary suture of the wound. Primary union. This patient was able to get her peg-leg three weeks after amputation, which was changed in December to an artificial leg constructed for end-bearing.

#### TREATMENT OF PENETRATING GUNSHOT WOUNDS OF THE CHEST WITH HEMORRHAGE INTO THE PLEURA

DR. L. W. HOTCHKISS read a paper with the above title, for which see page 707.

DR. WILLY MEYER stated that years ago he treated a slight dagger wound of the lung in which, although there was some hæmothorax, everything went very nicely. He referred to Doctor Hotchkiss' statement that in the second case reported emphasis was laid on the cleaning out of the pleural cavity, and Doctor Meyer considered that, if this had been done from the start thoroughly, it might have simplified the further course of the case materially. Personally, he thinks that if there be a hæmothorax and compression of the lung with no change in pulse, respiration or temperature, the patient should be left alone. But if the thoracic cavity is filled with a large amount of blood clot and there is tendency to infection he would not hesitate a moment to make a long intercostal incision which would allow the surgeon to inspect the thoracic cavity and to clear out every bit of what is in there. If the case were very much infected perhaps washing might do some good, but he believes the thoracic cavity is in that respect not different from the peritoneal cavity, where the majority of surgeons have given up washing as a necessary procedure. He strongly advocates in every case thoracic drainage, that is, the post-operative thoracic drainage. He is convinced that this is the best way to treat every infected thoracic cavity no matter for what purpose. He also advocates the closure of the main incision, as in the peritoneum, making a stab-wound for drainage, using Kenyon's method.

DR. ROBERT T. MORRIS stated that when hemorrhage from the lung was continuous it might sometimes be stopped by the injection of nitrogen gas directly into the chest cavity. He also called attention to the fact that not only blood-clot might be present but also lymph-clot in the chest cavity, and these clots should be removed with great care, usually with difficulty even through a large opening. He referred to three cases in all of which it was difficult to get out the clot and in these he used a solution of pepsin and was thereby able to liquefy and drain out quantities of clots.

DR. HERMANN FISCHER stated that he had seen a great number of shell wounds of the chest and gunshot wounds during his service at the front in 1915 and 1916, and stated that the treatment depended largely upon the weapon with which the wound was inflicted. Rifle bullet wounds of the chest heal quickly. The patients were usually given morphine and an ice-



## PENETRATING GUNSHOT WOUNDS OF THE CHEST

bag applied to the chest, and, as a rule, they made satisfactory recoveries. He mentioned the fact that some through-and-through shot wounds of the chest do not cause much anxiety. Shell wounds, however, are an entirely different matter and comparatively few soldiers so injured by the tremendous artillery now used ever reach the field hospital, their injuries proving fatal very quickly. Doctor Fischer stated that only five such injuries had come under his observation and that usually there is a large defect in the lung, part of it being torn away, and these cases are always severely infected and complicated by gangrene of the lung. In his treatment he used the same procedures as in peace surgery, wide opening of the chest with drainage at the most dependent point. If the wound occurs in the upper part of the chest a secondary counter-incision near to the diaphragm is advocated in order to properly drain the pus. Of the five cases coming under his care two proved fatal; in one it was necessary to resect four or five ribs, but this patient recovered, losing, however, the function of the lower lobe of the right lung.

DR. JOHN DOUGLAS inquired as to what symptoms should lead one to subject the patient to immediate surgical interference. In war surgery as mentioned by Doctor Fischer, the severer cases do not reach the base hospitals, usually not the first casualty station, while in civil practice a number of such cases are seen in the hospitals. He stated that he had seen a number of such cases at Bellevue Hospital in which it was difficult to determine whether the hemorrhage was continuing and justified surgical intervention. He cited an instance of a man shot in the back, with severe hemorrhage into the pleural cavity. He was in desperate condition, and an attempt at drainage seemed useless unless the hemorrhage could be controlled; this patient died before the preparation for operation was completed. He mentioned another case of attempted suicide where there was a large gaping wound about the fifth space, just missing the heart, where every time the man breathed the lung could be seen coming up and blood spurting out of the chest wound. It was obvious that something should be done and he therefore sewed up the large rent in the lung, but the man died. Considering these two instances he would like information as to how to determine which cases to operate on with regard to controlling hemorrhage, not with regard to drainage for infection which occurred later.

DR. LUCIUS W. HOTCHKISS, in closing, said that Doctor Fischer's report coincided entirely with the French and English reports: The losses on the field from hemorrhage and in the first dressing station from hemorrhage and asphyxia being very great. The cases considered by him were those lung shots which get through to the casualty clearing station and later to the base hospital.

With regard to Doctor Meyer's comments as to washing out the pleural cavity, Doctor Hotchkiss stated that he had no fear in washing out the pleural cavity in old cases, and stated that in chest wounds the experience in the field has been that washing has been of the greatest value in these

## NEW YORK SURGICAL SOCIETY

cases of infected hæmothorax. This was usually done by the introduction of a tube, the Dakin or normal salt solution being used.

Lockhart reports 170 cases in which there were only three cases of septic hæmothorax, and Doctor Hotchkiss stated that he had never seen such a case although he had seen a number of shot wounds of the chest developing empyema treated by low incision and drainage, some of the patients recovering and some succumbing. From his information regarding the field cases he does not believe it to be a common form.

In reply to Doctor Douglas' query, he cited a case with severe primary hemorrhage where he operated. From the hæmatoma forming over the ribs he inferred that there had been an injury to the intercostal vessels. On exploration he found and resected a shattered rib and, seeing a hole in the lung, fished out the clots, sewed up the wound, and at the end of three weeks this patient left the hospital in good condition.

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